BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

(19) Europäisches Patentamt
European Patent Office
Office eur péen des brevets

(11) EP 0 947 592 A1

(12) EUROPEAN PATENT APPLICATION

published in accordance with Art. 158(3) EPC

(43) Date of publication:
06.10.1999 Bulletin 1999/40

(21) Application number: **97939214.9**

(22) Date of filing: **08.09.1997**

(51) Int. Cl.[6]: **C22C 9/04**, C22F 1/08

(86) International application number:
PCT/JP97/03152

(87) International publication number:
WO 98/10106 (12.03.1998 Gazette 1998/10)

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IT LI NL PT SE

(30) Priority: **09.09.1996 JP 23759196**
01.11.1996 JP 29177596
13.01.1997 JP 402797
17.02.1997 JP 3184997
26.03.1997 JP 7411197
20.05.1997 JP 16783397
20.05.1997 JP 16783497
20.05.1997 JP 16783597
20.05.1997 JP 16783697
20.05.1997 JP 16783797

(71) Applicant: **TOTO LTD.**
Kitakyushu-shi, Fukuoka-ken 802 (JP)

(72) Inventors:
- **NAKAMURA, Katsuaki**
  Kitakyushu-shi Fukuoka 802 (JP)
- **ASHIE, Nobuyuki**
  Kitakyushu-shi Fukuoka 802 (JP)
- **MATSUBARA, Ryuji**
  Kitakyushu-shi Fukuoka 802 (JP)
- **HAMASAKI, Masanao**
  Kitakyushu-shi Fukuoka 802 (JP)

(74) Representative: **HOFFMANN - EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) COPPER ALLOY AND METHOD OF MANUFACTURING SAME

(57) The purpose of this invention is to provide metals, particularly brass, that have excellent mechanical strength, machinability, ductility in hot working, and corrosion resistance. The brass of this invention is roughly classified into four types of "α+γ", "α+β+γ", "α+ normal β", and "α+ reinforced β". The α+γ type of brass has crystal structure of α+γ phases at room temperature, and its areal ratio of the α phase is 97-70%. The α+β+γ type of brass has crystal structure of α+β+γ phases at room temperature, and the areal ratio of each of the β and γ phases are 3-30. In these two types of brass, the γ phase contains 8% or more of Sn. The α+ normal β type of brass has crystal structure of α+β phases at room temperature, and its areal ratio of the β phase is 20% or more. The α+ reinforced β type of brass has crystal structure of α+β phases at room temperature, its areal ratio of the β phase is 15% or more, and the β phase contains 1.5% by weight or more of Sn. All the types of brass have crystal structure of α+β phases in the recrystallization temperature zone, and its areal ratio of the β phase is 30-80% in this temperature zone. The crystal grain sizes of the α and β phases are 15 μm or less, preferably 10 μm or less, and the average minor axis of crystal grains of the γ phase is 8 μm or less, preferably 5 μm or less. The α+γ and α+β+γ types of brass have their apparent Zn contents of 37-46% by weight and overall Sn contents of 0.9-7% by weight. The other two types of brass have apparent Zn contents of 37-44% by weight.

Type	Final Crystal Structure at Room Temperature	Crystal Structure in Hot Working	Composition: Apparent Zn Content	Composition: Sn
α + γ	α-phase ratio: 97 - 76% (93 - 70) γ-phase ratio: 3 - 30% (5 - 30) Grain size of α-phase: 15 μm or less (10 μm or less) Minor diameter of γ-phase grains: 8 μm or less (5 μm or less) Sn in γ-phase: 8% by wt. or more		37 - 46% by wt. (38 - 46)	0.9 - 7% by wt.
α + β + γ	β-phase ratio: 3 - 30% γ-phase ratio: 3 - 30% Grain size of α- and β-phase: 15 μm or less (10 μm or less) α-phase ratio: 40 - 94% Minor diameter of γ-phase: 8 μm or less (5 μm or less) Sn in γ-phase: 8% by wt. or more	α + β 2-phases β-phase ratio: 30 - 80%		
α + Normal β	β-phase ratio: 20% or more (25% or more) Grain size of α- and β-phase: 15 μm or less (10 μm or less)	Grain size: 15 μm or less (10 μm or less)	37 - 44% by wt. (38 - 44)	Less than 0.5% by wt.
α + Reinforced β	β-phase ratio: 15% or more (20% or more) Grain size of α- and β-phase: 15 μm or less (10 μm or less) Sn in β-phase: 1.5% by wt. or more			0.5 - 7% by wt.

*: The percentage in parentheses is preferable.

Fig. 30

EP 0 947 592 A1

Descripti n

1. FIELD OF THE INVENTION

[0001] This invention relates to metals and to a method of manufacturing the metals and metal products manufactured using these metals. Although this invention is mainly related to Cu-Zn-based copper alloy, that is brass, and a method of manufacturing brass, the principle of this invention is not limited only to brass.

2. BACKGROUND OF THE INVENTION

[0002] Metals such as aluminum and stainless steel have been known to present 1000% or higher elongation. This excellent elongation is obtained because the strain is released by grain boundary sliding of crystal grains. The grain boundary sliding works most effectively when an external force of such a strain rate as 0.01/sec. This is why aluminum and stainless steel show high ductility when they undergo such low-rate external force. However, when an external force of a high strain rate exceeding 0.1/sec is given to crystal grains, the grain boundary sliding does not work effectively and crystal grains undergo substantial dislocation, thereby developing cracks in the metal.

[0003] As known in the art, to avoid crack initiation by external high-rate force, metals may be recrystallized by thermal energy or a strain energy due to deformation in working (dynamic recrystallization). Dynamic recrystallization for improving ductility is practically employed in manufacturing metals such as brass.

[0004] Conventional brass has realized 100% or a little higher elongation by a high-rate external force of a 0.1/sec strain rate. At present it is difficult, however, for the conventional art to realize further higher elongation. To realize higher elongation against an external high-rate force, the recrystallization rate needs to be increased. However, if metals are placed in such high-temperature condition as to increase the heat energy needed for recrystallization, crystal grains will coarsen before working force works to the grains and as a result dynamic recrystallization will not occur in working. Therefore, since the conventional working force is given at a lower temperature than the temperature above which crystal grains coarsen, enough energy to increase recrystallization rate is not achieved.

[0005] Brass is applied to a wide variety of applications, and properties required to brass differ depending on the application. For example, brass for forging requires high ductility against an external high-rate force mentioned above. Brass applied to parts kept contact with water (valves, faucet fittings, etc.), requires high corrosion resistance and high erosion resistance to water. Furthermore, high strength and machinability are also required in various applications.

[0006] Copper alloy known to have excellent corrosion resistance to water is Cu-Zn-Sn-based copper alloy (JIS C4641) or naval brass bar, and Cu-Zn-based copper alloy (JIS C6782) or high tensile brass bar. Corrosion resistance of brass mainly means resistance to dezincing. Because of the difference of ionization tendency of Cu and Zn, Zn is liable to dissolve in water faster than Cu and, as a result, the brass reduces its Zn content and loses strength with the lapse of time. Such phenomenon is called dezincing, which becomes the important problem when the brass is applied to water-contact parts.

[0007] Improvement of the corrosion resistance disclosed by Examined Japanese Patent Publication No. Sho6158540, 1986, describes the brass which is made by adding Pb, Fe, Ni, Sb and P to Cu-Zn-Sn-based copper alloys and is substantially in the α phase. Improvement in the corrosion resistance disclosed by Laid-open Japanese Patent Publication No. Hei6108184, 1994, describes the brass in which a Cu-Zn-Sn-based copper alloy to which Pb, Fe, Ni, Sb and P are added is, after being subjected to hot extrusion or hot drawing, heat-treated at 500°C-600°C for 30 min - 3 hours to obtain brass which is substantially in α phase. As mentioned above, to realize brass of good corrosion resistance, the conventional arts have produced brass which is substantially in a single phase of α phase without depositing the β phase, which is very inferior in corrosion resistance.

[0008] However, the above-mentioned conventional brass which is substantially of the single α phase is inferior in mechanical strength and machinability. On the other hand, though the conventional brass having crystal structure of $\alpha + \beta$ type has good mechanical strength and machinability, it is inferior in corrosion resistance since the β phase is extremely inferior in corrosion resistance. In other words, in the conventional arts, it is difficult to manage to enhance corrosion resistance and mechanical strength as well as machinability simultaneously.

[0009] It is an object of the invention to provide metals which present high ductility to an external high-rate force.

[0010] Another object of the invention is to provide brass which presents high ductility to an external high-rate force.

[0011] A further object of this invention is to provide brass which presents good corrosion resistance and machinability.

[0012] A still further object of this invention is to provide brass which excels in various properties such as ductility, mechanical strength, machinability and corrosion resistance.

[0013] Still further object of this invention is to provide production methods of the brass mentioned in the above objects.

[0014] A still further object of this invention is to provide metal products and brass products which excel in various

properties.

3. DISCLOSURE OF INVENTION

[0015] A metal according to the first aspect of this invention is so constructed that, when it is given an external force and deformed, the strain in the crystal structure will disperses. In the metal, the strain energy caused by the deformation can work as an energy source for recrystallization. As a result, when an external high-rate force is given to the metal, the strain in the crystal structure disperses without concentrating locally, thereby producing a large strain energy which enables recrystallization and prevents crystal grains from dislocating. Thus a metal that presents high ductility by an external high-rate force is provided.

[0016] A method of manufacturing metal products according to the second aspect of this invention contains hot-working process of metal on conditions that if strain energy of metal crystals deformed by an external force in hot working is denoted by SE, and heat energy given to the metal crystals by heating in hot working is denoted by TE;

SE+TE > Minimum energy necessary for recrystallization of deformed metal crystal

TE < Energy necessary for a crystal grain to coarsen under the condition of no external-force.

[0017] In the production method according to this invention, a metal in hot working is not heated up to such high temperature as the crystal grains coarsen so as to reduce the ductility. In stead, the method offers a way to satisfy the conditions needed for the strain energy in metal caused by deformation due to an external force to become large enough so that effective recrystallization takes place even at a relatively low temperature (energy due to deformation is considered potential energy caused by dislocation). In an example of this invention, such a conditions is adjusted so that the metal crystal structure to be subjected to hot working develops strain dispersedly when subjected to an external force (dispersion of strain is microscopically considered to be dispersion of dislocation). As a result, crystal grains do not coarsen when heated, and dynamic recrystallization takes place effectively in a metal when an external force in working is given, thus realizing high ductility to an external high-rate force.

[0018] One type of crystal structure that develops strain when given an external force is a mixture of relatively soft and hard crystals of sufficiently fine grain size. In such crystal structure, when given an external force, soft crystals deform (supposedly due to the grain boundary sliding between soft and hard crystals), and the deformed soft crystals migrate and disperse. The crystal structure mentioned above can be realized by an alloy which contains two kinds of metal elements and deposit a soft and hard crystal phase, typically brass, which is an alloy of Cu and Zn. Embodied examples of an alloy of this invention are $\alpha+\beta$-,$\alpha+\beta+\gamma$- and $\alpha+\gamma$- type brass of fine crystal grains of 15 μm or smaller in diameter.

[0019] To accomplish effective results, a third element-contributing to accelerate recrystallization rate (to accelerate nucleation rate for recrystallization) may be solid-dissolved in soft crystals of the alloy made of two kinds of metals as mentioned above. The typical third element, for example, is Sn in brass the atomic radius of which resembles closely to the above-mentioned two kinds of metal elements so that substitutional solid solution in soft crystals may take place.

[0020] Brass according to the third aspect of this invention possesses $\alpha+\beta$ crystal structure within the temperature range for recrystallization, and also satisfies the following conditions within the recrystallization temperature range :

(A1) Areal ratio of β phase is 30% - 80%;
(A2) Average crystal grain sizes of α and β phases are 15 μm or smaller, preferably smaller than 10 μm in; and
(A3) The α phase exists dispersedly.

A desirable example of the brass according to this invention has the following high hot ductility within the recrystallization temperature range:

(1) The brass is not damaged when given 100% strain at a strain rate of 1/sec;
(2) The brass is not damaged when given 200% strain at a strain rate of 0.1/sec,
(3) The brass is not damaged when given larger than 200% strain at a strain rate of 0.01/sec; or
(4) The brass is not damaged when given larger than 600% strain at a strain rate of 0.001/sec.

[0021] The conventional brass cannot realize such high elongation percentage as mentioned above. Also, the conventional superplastic materials (e.g. aluminum and stainless steel) are not provided with good ductility against high-rate strain as in (1) and (2) above.

[0022] The brass according to this invention can be roughly classified into four types called as follows in this specification: "$\alpha+\gamma$ type," "$\alpha+\beta+\gamma$ type," "α + normal β type," and "α + reinforced β type."

[0023] The "α+γ type" brass possesses α+γ crystal-structure in room temperature, and also in room temperature satisfies the following conditions:

(B1) The areal ratio of γ phase is 3% - 30%, preferably 5%-30%;
(B2) Average crystal grain size of the α phase is 15 μm or smaller, preferably 10 μm or smaller;
(B3) Average crystal grain size of the γ phase is 8 μm or smaller, preferably 5 μm or smaller; and
(B4) The above-mentioned γ phase exists on the α phase grain boundary.

This type of brass excels in machinability.

[0024] The "α+β+γ type" brass possesses α+β+γ crystal-structure at room temperature, and also at room temperature satisfies the following conditions:

(B1) The areal ratio of the α phase is 40% - 94%;
(B2) The areal ratios of both the β and γ phases are 3% - 30% ;
(B3) Average crystal grain sizes of β and γ phases are 15 μm or smaller, preferably 10 μm or smaller; and
(B4) Average crystal grain size of the γ phase is 8 μm or smaller, preferably 5 μm or smaller.

This type of brass also excels in machinability.

[0025] Further, this type of brass may preferably be manufactured to satisfy the following conditions at room temperature:

(B5) The γ phase contains 8% by wt. or more Sn, and
(B6) The β phase is surrounded by the γ phase mentioned above.

The brass satisfying the above conditions comes to excel in corrosive resistance and stress corrosion cracking resistance (SCC resistance).

[0026] The "α+normal β type" brass possesses α+β crystal-structure at room temperature, and also at room temperature satisfies the following conditions:

(B1) The areal ratio of β phase is 20% or larger, preferably 25% or larger, and
(B2) Average crystal grain sizes of the β and γ phases are 15 μm or smaller, preferably 10 μm or smaller.

This type of brass excels in machinability and strength.

[0027] The "α + reinforced β type" brass possesses α+β crystal-structure at room temperature, and also at room temperature satisfies the following conditions:

(B1) The areal ratio of the β phase is 15% or larger, preferably 20% or larger,
(B2) Average crystal grain sizes of the α and β phases are 15 μm or smaller, preferably 10 μm or smaller, and
(B3) The β phase contains 1.5% by wt. or more Sn.

This type of brass excels in machinability, corrosion resistance and SCC resistance.

[0028] In all types, satisfactory examples present such good hot ductility that does not cause any damage even if 400% strain at a strain rate of 0.01/sec is given within the recrystallization temperature range. A satisfactory example also shows furthermore excellent properties in room temperature as described in (1) - (3) below:

(1) Good machinability

[0029] Machining resistance index based on, as the reference, the free-cutting brass bar conforming to JIS (Japanese Industrial Standard) C 3604 is 80 or higher.

(2) Good corrosion resistance

[0030] Through dezincing tests conducted in accordance with the technical standard T-303 of JBMA (Japan Brass Makers Association), corrosion resistance was confirmed as follows: If the direction of the maximum dezinking penetration depth is parallel with the working direction, the maximum dezinking penetration depth is not deeper than 100 μm, and if the direction of the maximum dezinking penetration depth is rectangular to the working direction, the maximum dezinking penetration depth is not deeper than 70 μm.

(3) Good SCC resistance

[0031] After a cylindrical specimen of brass of this invention is exposed to an ammoniacal atmosphere over 14% ammonia water and then a load is applied to the specimen for 24 hours, the maximum stress below which the specimen does not crack is not lower than 180 N/mm^2.

[0032] No conventional metals can satisfy the above-mentioned conditions. For example, SPZ (zinc aluminum) and aluminum are, when placed in water, inferior in corrosion resistance, and particularly aluminum develops pitting. In addition, because these metals are tough, they are also inferior in machinability.

[0033] A method of manufacturing brass according to the fourth aspect of this invention contains a step of manufacturing brass castings by performing casting under the following conditions:

(1) Apparent Zn content in material composition is 37%-46% by wt.,
(2) The solidification rate after casting is 5×10^1-10^5K/sec, preferably 10^2 - 10^5K/sec, and
(3) The cooling rate after solidification is, until the temperature drops to 400°C or below, 5K/sec or higher.

[0034] The brass castings produced by the above-mentioned method show high hot ductility, because the method satisfies the conditions required for the brass according to the third aspect of this invention, within the recrystallization temperature range.

[0035] The production method of this invention may further contain the step of making brass extrusions by performing, after performing casting as mentioned above, hot extrusion of the above-mentioned brass castings within the temperature range of 480°C-650°C, preferably 480°C-600°C. The cooling rate after the hot extrusion is, preferably 0.4K/sec or higher, until the temperature is lowered to 400°C or below. Consequently, the brass extrusions satisfy the conditions required for the brass according to the third aspect of this invention.

[0036] A method of manufacturing the brass according to the fifth aspect of this invention contains a step of producing brass extrusions by hot-extruding brass the apparent Zn content of which is 37%-46% by wt. under the following conditions:

(1) Temperature in the extrusion is 460°C-650°C, preferably 480°C-600°C, and
(2) Reduction in the extrusion is 90% or higher, preferably 95% or higher.

[0037] This method also provides the brass extrusions which satisfies the conditions required for the brass according to the third aspect of this invention. The cooling rate after hot extrusion is preferably 0:4K/sec or higher, until the temperature is lowered to 400°C or below. Because of this rapid cooling, crystal grains do not coarsen even after the cooling, and thus the crystal structure having such finer crystal grains as 15 μm or smaller, which is one of the characteristics of this invention, can be obtained.

[0038] This production method may further contain the step of making brass forgings by reheating and hot-forging the above-mentioned brass extrusions within the temperature range of 480°C-750°C. Consequently, the brass forgings also satisfy the conditions required for the brass according to the third aspect of this invention. The strain rate in hot-forging is preferably 1/sec or higher. Such rapid hot-forging will not increase the crystal grain size. The cooling rate after hot forging is preferably 0.4K/sec or higher, until the temperature is lower to 400° C or below. Due to this rapid cooling, crystal grains do not increase in diameter even after the cooling, thus remaining as fine crystal grains of 15 μm or smaller size.

[0039] For producing the "α+γ type" of the brass of this invention according to the above-mentioned production method, when the Sn content of brass is 0.9 - 7% by wt., cooling conditions of 0.4 - 5K/sec may be selected until cooling rate after hot extrusion or hot forging is lowered to 400°C or below. Alternatively, when the Sn content of brass material is also 0.9 - 7% by wt., following the hot forging step, a heat-treatment step may be added so that the brass forging can be heated and kept at 400-550°C for 30 sec or longer and then cooled at a cooling rate of 0.4-5K/sec until its temperature is lowered to 400 °C or below.

[0040] For producing "α+β+γ type" of the brass of this invention according to the above-mentioned production method, when the Sn content of the brass is 0.9 - 7% by wt., a cooling condition of 0.4 - 10K/sec may be selected until the temperature after hot extrusion or hot forging is lowered to 400°C or below. Alternatively, in stead of adjusting the cooling rate as mentioned above, a heat-treatment step following the hot forging process may be added so that the brass forging can be heated and kept at 450-550°C for 30 sec or longer and then cooled at a cooling rate of 0.4-10K/sec until its temperature is lowered to 400°C or below.

[0041] For producing the "α + reinforced β type" of the brass of this invention according to the above-mentioned production method, when the Sn content of the brass is 0.5-7% by wt. and the apparent Zn content is 37-44% by wt., a cooling condition of 5 - 1000K/sec may be selected until the cooling rate after hot extrusion or hot forging is lowered to 400°C or below. Alternatively, in stead of adjusting the cooling rate as mentioned above, a heat-treatment step following

the hot forging process may be added so that the brass forging can be heated and kept at 475-550°C for 30 sec or longer and then cooled at a cooling rate of 5-1000K/sec or higher until its temperature is lowered to 400°C or below.

[0042] A method of producing the brass according to the sixth aspect of this invention contains the step of: heating and then cooling the brass of the apparent Zn content of 37-46% by wt., and controlling at least any one of heating temperature, heat retaining time and cooling rate so that the crystal structure of the cooled brass can be selected out of the $\alpha+\beta$ $\alpha+\beta+\gamma$, and $\alpha+\gamma$ types. For example, under conditions of the same heating temperature and heat retaining time, the cooling rate may be controlled to the lowest rate for obtaining the $\alpha+\gamma$ type, and to a higher rate for obtaining the $\alpha+\beta+\gamma$ type. and to the highest rate for obtaining the $\alpha+\beta$ type.

[0043] The copper alloy (typically brass) produced according to the seventh aspect of this invention is provided with the following good machinability and mechanical strength: The machining resistance index based, as a reference, on the free cutting brass bar conforming to JIS (Japanese Industrial Standard) C 3604 is 80 or higher, and o.2% yield strength or the yield stress is 300 N/mm^2 or more. Conventionally, no copper alloy has been provided with such good machinability and strength. For example, although bronze has cutting resistance index of 80 or more, its 2% yield strength is only about 80 N/mm^2 and its tensile strength is only about 220 N/mm^2. It is generally difficult to improve the strength of bronze because the copper content of bronze is 79% or more. One of the ways of improving the strength of bronze is to increase the Sn content of bronze. However, bronze of a higher Sn content often develops a defect called shrinkage cavities (foams in solidification contraction) in casting, thus reducing strength. On the contrary, copper alloys of this invention, especially brass, maintain an adequate balance between copper excelling in corrosion resistance and zinc excelling in machinability, providing improved machinability and strength.

[0044] The copper alloys (typically brass) according to the eighth aspect of this invention are provided with the following stress corrosion cracking resistance: When a cylindrical specimen of a copper alloy of this invention is exposed to an ammoniacal atmosphere over 14% ammonia water for 24 hours under a load, the maximum stress under which the specimen does not crack is 180 N/mm^2 or more. For improving SCC resistance, improvements in strength and corrosion resistance are essential (though other factors are also required). The SCC resistance is improved in this invention by taking advantage of excellent corrosion resistance of copper. Incidentally, bronze is less durable to stress and causes plastic deformation by stress of about 100 N/mm^2.

[0045] The brass according to the ninth aspect of this invention has the following good machinability and corrosion resistance: Its machining resistance index based, as the reference, on the free-cutting brass bar is 80 or higher, and when a dezinking corrosion test is conducted in accordance with a technical standard T-303 of JBMA, the maximum dezinking penetration depth is 100 μm or less if the direction of the maximum dezinking penetration depth is parallel with the working direction, and 70 μm or less if the direction of the maximum desinking penetration depth is rectangular to the working direction. Incidentally, free-cutting brass bars are inferior in corrosion resistance, and when a dezinking test is conducted as mentioned above, the maximum dezinking penetration depth reaches approximately 200 μm.

[0046] One of the ways of improving machinability of brass is to reduce the average crystal grain size to 15 μm or smaller, preferably 10 μm or smaller. In addition, it is desirable to adjust the crystal structure so that it contains the α phase and parts that exists between the grain boundary of the α phase and is softer or harder than the α phase. The parts softer than the α phase are composed of such metals as Pb and Bi, that is, metals other than the metal constituting the α phase. The parts harder than the α phase are composed of the β or γ phases, intermetallic compounds such as FeSi and FeP, or oxides of Cu and Mg. When crystal structure of the $\alpha+\beta$ type is compared to that of the $\alpha+\gamma$ type, the latter shows higher machinability than the former, because the difference of hardness between two phases is larger in the $\alpha+\gamma$ type of crystal structure than in the $\alpha+\beta$ type of crystal structure.

[0047] To improve the corrosion resistance as well as machinability, brass may be produced by the following method. For example, for the $\alpha+\gamma$ type of crystal structure, it is effective to make the γ phase contain Sn preferably in a quantity 8% by wt. or more. For the $\alpha+\beta$ type of crystal structure, it is effective to make the β phase contain third elements (e.g. Sn, Si, Al, Sb, Ge or Ga) for the purpose of improving corrosion resistance. To make the β phase contain Sn, the Sn concentration in the phase is preferably 1.5% by wt. or higher. Further, it is also effective to produce crystal structure composed of the α phase, β phase and parts which surround crystal grains of the β phase and offers higher corrosion resistance than that of the β phase. The parts which offer higher corrosion resistance than the β phase does is, for example, the γ phase that contains Sn of 8% by wt. or more. For the $\alpha+\beta+\gamma$ type of crystal structure, it is desirable to make the average minor axis of crystal grains in the γ phase 8 μm or smaller so that the structure does not develop brittleness of the γ phase.

[0048] The brass having machinability and corrosion resistance improved according to this invention is applicable to a variety of applications, especially to water piping parts. Because the average crystal grain size of the brass of this invention is small, the brass is rather inferior in cold ductility. However, for applications to water piping parts, which do not require such high cold ductility as martensite and shape memory alloys possess, the brass of this invention can fully satisfy the product quality required for the parts.

[0049] A further aspect of this invention is to provide wide variety of products using the metal or brass of this invention. A still further aspect of this invention is to provide production equipment usable for producing the metal or brass of this

invention.

4. BRIEF DESCRIPTION OF THE DRAWINGS

[0050] The foregoing features of the invention, as well as the invention itself, may be more fully understood from the following detailed description with reference to the attached drawings, in which:

FIG. 1 is a table presenting properties of three crystal phases of brass, pure Cu, pure Zn and pure Sn;
FIGs. 2A-2C are tables presenting composition, crystal structure and properties of examples of this invention and examples of conventional brass as references;
FIG. 3 is a flow diagram illustrating an example of production process of brass product;
FIG. 4 is a table presenting casting and hot-extrusion conditions of two examples of brass production method of this invention and of a conventional method;
FIG. 5 is a table presenting hot-forging conditions and crystal structure in two examples of brass production method of this invention and of a conventional method;
FIG. 6 is a graph showing ductility test results (unit strain and strain rate) within the recrystallization temperature zone;
FIG. 7 is a table presenting machinability test results;
FIG. 8 is a perspective view illustrating a machinability test method;
FIG. 9 is a graph showing erosion-resistance test results;
FIG. 10 is a sectional view illustrating a erosion-resistance test method;
FIG. 11 is a sectional view illustrating a SCC resistance test method;
FIG. 12 is a table presenting SCC resistance test results;
FIG. 13 is a table presenting composition and corrosion-resistance test results of samples relating to the "α + reinforced β type" of brass;
FIG. 14 is a graph showing the relationship between Sn concentration in the β phase and the cooling time down to 400°C;
FIG. 15 is a table presenting the effectiveness of heat treatment for the "α + reinforced β type" of brass of this invention;
FIG. 16A is a microscopic photograph showing crystal structure of an example of the "α + γ type" of brass of this invention;
FIG. 16B is a grain structure drawing prepared based on FIG 16A;
FIG. 17A is a microscopic photograph showing crystal structure of an example of the "α+β+γ type" of brass of this invention;
FIG. 17B is a schematic drawing of the crystal structure prepared based on FIG 17A;
FIG. 18 is a table presenting composition and corrosion-resistance test results of samples relating to the "α+γ type" and "α+β+γ type" of brass of this invention;
FIG. 19 is a flow diagram illustrating an example of manufacturing process of parts contacting with water prepared using the "α+γ type" and "α+β+γ type" of the brass of this invention;
FIG. 20 is a flow diagram illustrating an example of manufacturing process of water-contact parts prepared using conventional brass;
FIG. 21 is a table presenting the effectiveness of heat treatment for the "α+β type" and "α+β+γ type" of brass of this invention;
FIG. 22A is a microscopic photograph showing crystal structure of brass for forging casted at a cooling rate of 19K/sec after casting;
FIG. 22B is a schematic drawing of crystal structure prepared based on FIG 22A;
FIG. 23A is a microscopic photograph in which a part of FIG 22A is enlarged;
FIG. 23B is a schematic drawing of crystal structure prepared based on FIG 23A;
FIG. 24A is a microscopic photograph showing crystal structure of brass for forging casted at a cooling rate of 1.3K/sec after casting;
FIG. 24B is a schematic drawing prepared based on FIG 24A;
FIG. 25A is a microscopic photograph in which a part of FIG 24A is enlarged;
FIG. 25B is a schematic drawing of crystal structure prepared based on FIG 25A;
FIG. 26A is a microscopic photograph showing crystal structure of a brass billet for forging prepared by hot-extruding brass having Sn content of 1.9% by wt. and then cooling the brass at a cooling rate of 30K/sec;
FIG. 26B is a schematic drawing of crystal structure prepared based on FIG 26A;
FIG. 27A is a microscopic photograph showing crystal structure of a brass forging prepared by hot-forging a brass billet shown in FIG. 26A and then cooling the forging at a cooling rate of 20K/sec;

FIG. 27B is a schematic drawing of crystal structure prepared based on FIG 27A;
FIG. 28A is a microscopic photograph showing crystal structure of a brass billet for forging prepared by hot-extruding brass with Sn content of 2.3% by wt. and then cooling the brass at a cooling rate of 30K/sec;
FIG. 28B is a schematic drawing of crystal structure prepared based on FIG 28A;
FIG. 29A is a microscopic photograph showing crystal structure of a brass forging prepared by hot-forging a brass billet shown in FIG. 28A and then cooling the forging at a cooling rate of 20K/sec;
FIG. 29B is a schematic drawing of crystal structure prepared based on FIG 29A;
FIG. 30B is a table presenting preferable conditions of crystal structure and composition of the brass of this invention;
FIG. 31 is a table presenting preferable conditions of casting and hot-extrusion when the brass of this invention is finally produced by hot extrusion;
FIG. 32 is a table presenting preferable hot-extrusion and hot-forging conditions when the brass of this invention is finally produced by hot forging;
FIG. 33 is a table presenting preferable conditions of hot extrusion, hot forging and heat treatment when the brass of this invention is finally produced by heat treatment;
FIG. 34 is a perspective view of an example of faucet fittings to which the brass of this invention is applied;
FIG. 35 is a sectional view of an example of water pipe to which brass of this invention is applied;
FIG. 36 is a sectional view of another example of water pipe to which the brass of this invention is applied;
FIG. 37 is a sectional view of a further example of water pipe to which the brass of this invention is applied;
FIG. 38 is a schematic side-view showing an example of a hot-water supply system provided with reducing valve and bypass valve to which the brass of this invention is applied;
FIG. 39 is a sectional view showing a reducing valve of the hot-water supply system of FIG. 38; and
FIG. 40 is a sectional view showing a bypass valve of the hot-water supply system of FIG. 38.

5. BEST MODE CARRYING OUT THE INVENTION

[0051] Applications of copper alloys of CU-Zn system cover a wide range, including water contact parts such as faucets and water supply pipes, electric household appliances, mechanical parts, architectural materials, gas fittings, and optical instrument parts. For these kinds of copper alloys, it is required to excel not only in general properties, such as mechanical strength, cold rollability, hardness, machinability, and polishability, but also in different properties required as water contact parts, such as corrosion resistance, erosion resistance, and resistance to stress corrosion cracking.

[0052] One principle of this invention attaches importance for improving the above-mentioned properties to properties of crystal phases of Cu-Zn alloys. As the crystal phases three phases, α, β and γ, have been known so far. The γ phase excels in corrosion resistance and mechanical strength, but it has not been tried to utilize such properties positively because of its high brittleness. The β phase has low corrosion resistance and has been considered to be unsuitable to water contact parts. The α phase excels in corrosion resistance and cold ductility but is inferior in strength and machinability. As mentioned above, properties of respective phases have been rendered a fixed idea, and no positive try to alter properties of crystal phases has so far been made. In this situation the inventors of this invention elucidated importance of the crystal grain size as a factor that affects the above-mentioned different properties as a result of concentrated studies on such factors. These studies made it clear, in the first place, that properties of brass can be altered by effective utilization of the γ phase, secondly that properties of brass can be improved in particular by the β phase, and thirdly that properties of brass can be improved by optimizing the crystal grain size as well.

[0053] As an actual means for depositing the γ phase and altering properties of the β phases, addition of Sn can be adopted. However, the addition of Sn is unsuitable to brass for forging because it lowers hot ductility of the brass. To solve this problem, the inventors conducted further studies on the hot ductility of alloys. As a result, it was proved fourthly that optimization of the grain size improves the hot ductility, and fifthly that optimization of the mixing ratio of the α and β phases secures dynamic recrystallization of the β phase, thereby improving the hot ductility.

[0054] The embodiments of this invention employ the above-mentioned study results. It will be useful to describe properties of the three above-mentioned crystal phases before describing embodiments of this invention. FIG. 1 shows properties of three phases which appear in Cu-Zn alloys and those of pure Cu, Zn and Sn.

[0055] As understandable from FIG. 1, pure Cu is inferior in yield strength and machinability (easiness to be machined) although it excels in corrosion resistance, ductility at room temperature and cold forgeability (easiness to be cold-forged). Instead, a Cu-Zn alloy to which Zn is added is conventionally used for wide range of applications. The Cu-Zn alloys come to differ in crystal structure by quantity of Zn to be added. When the apparent Zn content of a Cu-Zn alloy is 37% or less by weight, the crystal structure becomes a single α phase, and when the apparent Zn content is larger than 37%, the β phase appears in the crystal structure of the alloy (as $\alpha+\beta$ or β type). When the apparent Zn content is increased furthermore, the γ phase appears (as $\alpha+\beta+\gamma$, $\alpha+\gamma$, or $\beta+\gamma$ type or single γ phase). Even when the true

Zn content is low, the apparent Zn content increases and the γ phase appears if Sn (having Zn equivalent of 2) is added and the alloy is subjected to a special heat treatment. Here the term "apparent Zn content" means "[(B+t • Q)/(A+B+t • Q)] × 100", where B is the Zn content (% by wt.), t is Zn equivalent (% by wt.) of an added third element, for example, Sn, and Q is the content of the third element (% by wt.).

[0056] Although the single α phase excels in corrosion resistance and cold forgeability, it is inferior in yield strength and machinability. Addition of Sn can improve the corrosion resistance and yield strength of the Cu-Zn alloys, but the 2% by wt or more addition of Sn tends to make the alloys brittle. The β phase has properties approximately contrary to the α phase in that the β phase excels in yield strength, hot forgeability (easiness to be hot-forged) and machinability although it is inferior in corrosion resistance and cold forgeability. One knowledge the inventors obtained is that addition of Sn to crystal grains of the β phase improves corrosion resistance and yield strength; particularly the corrosion resistance is improved to a degree nearly comparable to the alloy of the single α phase. The γ phase appears when Sn is added in a specific quantity or more to the Cu alloy. The γ phase excels in corrosion resistance and yield strength although it is brittle.

[0057] In this description the "corrosion resistance" of copper alloys means mainly resistance to dezinking corrosion. The dezinking corrosion is defined as such a phenomenon that because of difference between Cu and Zn in the ionization tendency, Zn is eluted into water earlier than other elements, thus decreasing the strength of the alloy with the lapse of time. This is a problem confronted when the Cu-Zn alloy is used.

[0058] In the Cu-Zn alloys (brass) according to this invention crystal phases that have different properties (including modified properties) as described above are appropriately combined, and also the crystal grain size is optimized. FIGs. 2A-2C show compositions and properties of 19 examples of the brass according to this invention in comparison with brass (as references) according to conventional technology.

[0059] Features of crystal structure of examples 1-19 are described below. In examples 1-5 the alloys have crystal structure of α+γ type, whose crystal grains are microcrystallized (to 15 μm or smaller), and the γ phase having improved properties is effectively utilized. In examples 6-12 the alloys have crystal structure of α+β +γ type, whose crystal grains are microcrystallized, and the β and γ phases which have improved properties are effectively utilized. Examples 13-15 have crystal structure of α+β type, whose crystal grains are microcrystallized. Examples 16-19 have crystal structure of α+β type, whose crystal grains are microcrystallized, and their β phase has properties improved by addition of Sn. Furthermore, in these examples 1-19, the ratio of respective crystal phases has been approximately adjusted. Details of crystal structure of these examples are described later.

[0060] The alloys of examples 1-19 were produced by casting brass samples having compositions shown in FIG. 2A under the production conditions according to the principles of this invention, hot-extruding these samples, and then hot-forging the extrusions (the actual production flow is shown in FIG. 3). The heat treatment conditions shown in FIGs. 2A-2C are casting temperatures and cooling methods. The cooling rate of air cooling is 0.8K/sec, and that of water cooling is 100K/sec.

[0061] In FIGs 2A-2C are listed as properties "0.2% yield strength (N/mm^2)" (tensile stress causing permanent elongation of 2%), "cold ductility (%)" (ductility in a cold working zone), "hardness (HV)", "hot ductility" (ductility in a hot working temperature zone, i.e. in a recrystallization temperature zone), "cutting resistance index", "corrosion resistance", "erosion resistance" and "stress corrosion cracking resistance" (SCC resistance).

[0062] In FIGs. 2A-2C evaluation of respective properties are marked. As to "0.2% yield strength", 300 N/mm^2 was evaluated as poor (X), 300 N/mm^2 or more and less than 35 N/mm^3 as good (o), and 350 N/mm^2 or more as excellent (©). As to the "hot ductility", if the maximum strain of a sample specimen was less than 100% when the specimen was subjected to a tensile test at a strain rate of 100 (/sec), it was evaluated as poor (X), and if the maximum strain was 100% or more, it was evaluated as good (o). As to the "cutting resistance index", if it was less than 80% with reference to free cutting brass bars (JIS C 3604) as a result of a cutting test described later, it was evaluated as poor (X), and if the index was 80% or more, it was evaluated as poor (X).

[0063] The "corrosion resistance" was evaluated in accordance with judgment criteria shown by a technical standard (JBMA T-303) of Japan Brass Makers Association on the result of dezinking tests conducted in accordance with the JBMA T-303. That is, in the case where the direction of dezinking penetration depth is parallel with the working direction, the maximum dezinking depth of 100 μm or less was evaluated as good (o), and in the case where the direction of dezinking penetration depth is rectangular to the working direction, the maximum dezinking depth of 70 μm or less was evaluated as good (o). The results that do not satisfy these criteria was decided as poor (X).

[0064] The "erosion resistance" was evaluated as good (o) when the tightening torque required for preventing the sample from leakage after the lapse of 1500 hours under the test conditions described later was less than 0.8 N • m, and as poor (X) when the tightening torque was 8% or more. The stress corrosion cracking resistance was evaluated as good (o) when the sample did not crack after the lapse of 24 hours under the test conditions described later, and as poor (X) when the sample cracked on the same condition as above.

[0065] As seen in FIGs. 2A-2C, samples 1-5 were evaluated as good (o) or excellent (©) as to the yield strength, cold ductility, corrosion resistance, erosion resistance and stress corrosion cracking resistance. Examples 1 and 2 were

evaluated as poor (X) as to machinability, and such evaluation is supposed to be for the reason that both the samples did not satisfy the optimum conditions where the β phase is to be 3% or more and the γ phase is to be 5% or more. Hot ductility of example 1 was also evaluated as poor (X); this evaluation is supposed to be for the reason that in the hot working the β phase did not reach 30% because the apparent Zn content was less than 38%.

[0066] All the properties of examples 6-12 were evaluated as good (o) or excellent (©).

[0067] Except the corrosion resistance and erosion resistance, all properties of examples 13-15 were evaluated as good (o) or excellent (©). The evaluation results of corrosion resistance and erosion resistance of examples 13-15 as poor (X) is supposed to be for the reason that these samples do not contain the γ phase, and that the Sn concentration in their β phase does not reach 1.5% by wt.

[0068] All the properties of examples 16-19 were evaluated as good (o) or excellent (©).

[0069] Advantages of examples of this invention are described below particularly in relationship to "hot ductility", "cutting resistance index", "erosion resistance", and "stress corrosion cracking".

[0070] First, advantages of examples of this invention in the aspect of the "hot ductility" are described. Good ductility is one of the most important properties of billets supplied for hot working such as hot forging. FIG. 1 shows one example of a production process using hot forging for brass products.

[0071] At the first step, a mixture of electrolytic copper, electrolytic zinc and scraps is melted and cast into an intermediate form. In the next step 2, the formed castings are rapidly cooled and extruded in the form of bar- or wire rod-shaped billets. In the next step 3, the bar- or wire rod-shaped billets are subjected to cold drawing, annealing and pickling. Then the billets are cut to a predetermined length.

[0072] In the subsequent step 4, the billets are heated for securing properties suitable for forging in the next step 5. In step 5, the hot billets are set into forging dies, and forged. Then, as preparation for progressing to step 6, the forgings are cooled. After the cooling, the forgings are pickled and shot-blasted to remove the thin oxide coating formed on the surfaces, and deburred. In the last step 7, through working of cutting, grinding and plating, final products are obtained. FIGs. 4 and 5 compare two examples of the production methods of this invention (methods 1 and 2 of this invention) in accordance with the production process shown in FIG. 3 in comparison with a conventional production method.

[0073] In FIG. 4, the "apparent Zn content" is involved in the mixing ratio of the materials melted at step 1 shown in FIG. 1, the "solidification rate at casting" and "cooling rate after casting" are involved in casting conditions at step 1, and the "extrusion temperature" and "cooling after extrusion" are involved in conditions of hot extrusion at step 2. In FIG. 5, the "grain size" means that of the billets after hot extrusion at step 2 (and also the crystal grain size of final products in this invention); the "β-phase ratio", "forging temperature" and "strain and strain rate" are involved in forging condition at step 5; and the "yield strength" and "α-, β-, and γ-phase ratios after forging" mean those of the products finished at step 7.

[0074] As shown in FIG. 4, as compared with the conventional method, the apparent Zn content of methods 1 and 2 of this invention is high (typically the quantity of Sn addition is large), the solidification rate at hot casting and the cooling rate after casting are high, the temperature in hot extrusion (at step 2) is low, and the cooling rate after the extrusion is high (practically the extrusions are cooled at 0.4K/sec or a higher rate). Furthermore, the sectional area reduction by extrusion is 90% or more, preferably 95% or more, which is not shown in FIG. 4.

[0075] These billets prepared by methods 1 and 2 of this invention can be forged at low forging temperature and at a high strain and strain rate (at step 5) as compared with the billets prepared by the conventional method. Such advantages are suppose to be for the reason that as shown in FIG. 5, the billets by methods 1 and 2 of this invention have smaller crystal grain size than that of billets obtained by the conventional method, and contain the β phase, which excels in hot ductility even at relatively low forging temperature, at an appropriate ratio. It is advantageous to allow forging at lower temperatures because deterioration of the forging equipment can be reduced. As shown in FIG. 5, furthermore, the yield strength of the products forged by methods 1 and 2 of this invention is substantially larger than that of products of the conventional forging.

[0076] FIG. 6 shows hot ductility of two kinds of billets, one produced by a method of this invention and the other produced by the conventional method (actually example 10 and reference 4, which are shown in FIGs, 2A-2C) in the forging temperature zone. The abscissa shows the strain rate (sec^{-1}), and the ordinate shows strain εL (%). Example 10 is obviously superior in hot ductility to reference 4.

[0077] Referring now to FIG. 7, advantages of examples of this invention in the "cutting resistance index are described. FIG. 7 shows results of cutting tests conducted on reference 3, examples 8, 10 and 11, free cutting brass bars (JIS C 3604), and brass of single σ phase. As depicted in FIG. 8, a main component force Fv was measured while cutting the circumferential surface of a round-bar sample 1 with a lath at two different speeds of 100 and 400 m/min. The cutting resistance index of each sample is expressed as percentage of a main component force of a free cutting brass bar which has been said to have the best machinability, to the main component force of each sample.

[0078] As shown in FIG. 7, the cutting resistance indexes of example 8, 10 and 11 reach near 90% of that of the free cutting brass bar having the best machinability with the results better than that of reference 3 and the single α-phase brass bar.

[0079] Referring now to FIGs. 9 and 10, advantages of examples of this invention in the "erosion resistance" are described. FIG. 9 shows results of erosion resistance tests on examples 8 and 11 and reference 4 shown in FIGs. 2A-2C, and FIG. 10 portrays the method of erosion resistance tests. As shown in FIG. 10, the erosion resistance tests were conducted using a cylindrical sample 5 having an orifice inside. After water was passed through the orifice at a flow velocity of 40 m/sec for a predetermined period of time, tightening torque required for tightening a disk seat 9 to seal the orifice 7 under hydraulic pressure of 4.9×10^5 Pa (5 kg/cm^2) was determined. As shown in FIG. 9, it can be seen that examples 8 and 11 have higher erosion resistance than that of reference 4.

[0080] Referring now to FIGs. 11 and 12, advantages of examples of this invention in the "strain corrosion cracking (SCC) resistance" are described.

[0081] In the SCC resistance test, a cylindrical sample placed in a glass desiccator 11 as shown in FIG. 11 was exposed to an atmosphere of NH_3 vapor for 24 hours, and then checked the sample on cracking. Fig. 12 shows test results (relationship between main stress and cracking) of examples 8, 11 and 15, and reference 4. From FIG. 9, it is realized that examples 8, 11 and 15 have higher SCC resistance than that of reference 4.

[0082] As described above, examples 1-19 of this invention shown in FIGs, 2A-2C have good properties. As in the preceding descriptions, examples 16-19 have properties improved by microcrystallizing the crystal structure of $\alpha + \beta$ type (to 15 μm or finer) and also by adding Sn to the β phase, and this type of brass according to this invention is hereinafter referred to as "α + reinforced β type". Examples 1-5 have properties improved by microcrystallizing the crystal grain size in the crystal structure of $\alpha+\gamma$ type and also by utilizing the γ phase. This type of brass is hereinafter referred to as "$\alpha+\gamma$ type." Examples 6-12 have properties improved by microcrystallizing the crystal grain size in the crystal structure of $\alpha+\beta+\gamma$ type and also by utilizing the γ phase. This type of brass is hereinafter referred to as "$\alpha+\beta+\gamma$ type." Examples 13-15 have properties improved by microcrystallizing the crystal grain size in the crystal structure of $\alpha+\beta$ type. This type of brass is hereinafter referred to as "α + normal β type."

[0083] The method of production and crystal structure of the above-mentioned three types of crystal structure of brass according to this invention are described below.

[0084] Referring now FIG. 13, the "α + reinforced β type" is first described. This type of crystal structure has an intercrystalline β phase that contains 1.5% by wt. or more of Sn between crystal grains of the α phase.

[0085] In FIG. 13 the compositions, apparent Zn content, Sn concentrations in the β phase and results of corrosion resistance tests (to dezinking corrosion) of examples 1-7 are listed. The Sn concentrations in the β phase were adjusted by heat and cooling treatment and quantitatively analyzed by EPMA analysis. The corrosion resistance was judged by the method described already in connection with FIGs. 2A-2C.

[0086] From FIG. 13 it is clear that the corrosion resistance is closely related to the Sn concentration in the β phase. In other words, 1.5% or more Sn concentration in the β phase is needed for securing sufficient corrosion resistance. Of the examples in FIG. 13, those of example nos. 3-7 satisfy this necessary condition, and belong to the "α + reinforced β type". Incidentally this type of brass, the β phase of which contains Sn in 1.5% or more concentration, has the Sn concentration of 1.5% by wt. or more and the apparent Zn content ranging from 37% at the minimum to 44% at the maximum by weight to the whole mass of the alloy.

[0087] The Sn concentration in the β phase is affected by conditions of heat treatment or hot working in the production process (for example, cooling rate, temperature and time of the heat treatment, etc.). FIG. 14 is a graph showing results of experiments on the relationship between cooling time for cooling from heat treatment temperatures down to 400°C and the Sn concentration in the β phase. From FIG. 14, it is realized that when the cooling rate in the period from the start of cooling down to 400°C is 0.4K/sec or higher (in the zone on the left side of point (1) in FIG. 14), the Sn concentration in the β phase becomes 1.5% by wt. or more. Further the experiments proved that as the upper limit of the cooling rate, the rates up to at least 1000K/sec are permissible. Furthermore, not only in the case where the heat treatment temperature is 550°C, but also even in such other cases as the heat treatment temperature of 510°C, the same experimental results as above were obtained.

[0088] FIG. 15 shows results of experiments conducted to study the effect of the heat treatment temperature (temperature of sample specimens in heat treatment) and heat treatment time (time in which the heat treatment temperature is retained) on the Sn concentration in the β phase and the areal occupation ratio of the β phase.

[0089] FIG. 15 reveals that the Sn concentration in the β phase increases with rise of the heat treatment temperature, or with extension of the heat treatment time. On the other hand, the areal occupation ratio of the β phase decreases with rise of the heat treatment temperature, or extension of the heat treatment time. Furthermore, if at least the heat treatment temperature shown in FIG. 15 is in the range of 475-550°C and the heat treatment time is 30 sec. or longer, it is possible to increase the Sn concentration in the β phase. Extending the heat treatment time increases the Sn content in the β phase, thus improving the corrosion resistance. However, taking economy of the heat treatment in the production process into consideration, the heat treatment time is preferably 3 hr or shorter.

[0090] In the next place, the "$\alpha+\gamma$ type" and "$\alpha+\gamma+\beta$ type" of brass are described below.

[0091] FIG. 16A is a microscopic photograph showing crystal structure of a brass sample, No. 7, represented in FIG. 18. FIG. 16B is a schematic drawing of crystal structure prepared on the basis of FIG. 16A. FIG. 17A is a microscopic

photograph showing crystal structure of a brass sample, No. 4, represented in FIG. 18. FIG. 17B is a schematic drawing of crystal structure prepared on the basis of FIG. 17A.

[0092] In the crystal structure shown in FIG. 16A the γ phase (black spots in the figure) is precipitated and grown on boundaries of crystal grains of the α phase (white areas in the figure), and the β phase has disappeared. This is a typical example of the "α+γ type" of this invention. The crystal structure shown in FIG. 17A contains the α and β phases, and the γ phase deposits on grain boundaries of the α phase (larger white areas in the figure)) and the β phase (smaller white areas in the figure) so as to surround the β phase. This is a typical example of the "α+β+γ type" of this invention. It is preferable that the average grain size (average of minor axes of crystal grains) is smaller than the average grain sizes of the α and β phases, for example, 8 μm or smaller, preferably 5 μm or smaller.

[0093] FIG. 18 tabulates brass samples, Nos. 1-7, of 7 examples related to the "α+γ type" and "α+β+γ type" of this invention (which differ from the examples shown in FIGs. 2A-2C). The items shown in FIG. 18 are the composition, apparent Zn content, areal occupation ratio of the "γ phase", test results of corrosion resistance (dezinking corrosion resistance), and Sn concentration in the γ phase. The corrosion resistance test was conducted by a method described in connection with FIGs, 2A-2C.

[0094] From FIG. 18 it is realized that if the areal occupation ratio of the γ phase is in the range of 3.0% to 20%, inclusive, good corrosion resistance is obtained. In FIG. 18 samples of Nos. 3-7 satisfy such above condition. These samples belong to the "α+γ type" or "α +β+γ type". In addition it was proved by experiments that if the above condition is satisfied, good hot ductility is secured.

[0095] The areal occupation ratio of the γ phase is affected by conditions of the heat treatment or hot working (for example, heat treatment temperature and cooling rate) which is carried out in the production process. FIG. 19 shows an example of the methods for producing brass products according to this invention. The production method shown in FIG. 19 forms brass of a Cu-Zn-Sn system having such compositions as samples, Nos. 3-7, shown in FIG. 18, by hot forging or hot extrusion. Subsequently, the formed intermediate products are subjected to heat treatment at temperature of 400°C or higher and 550°C or lower for 30 sec or longer retaining time, and then cooled down to 400°C at a cooling rate of 0.4K/sec or more and 10K/sec or below. Through the heat treatment and cooling, the crystal structure of the formed intermediate products turns to the "α+γ type" or "α+β+γ type". After that, the formed intermediate products are machined, ground or plated.

[0096] Incidentally, conventional common production methods have made forming as shown in FIG. 20 by casting. The casting needs rather many steps. The example of production method of this invention shown in FIG. 19 can carry out forming without hot forging and hot extrusion, thus decreasing the number of production steps as compared with the conventional method using the casting step.

[0097] FIG. 21 shows results of experiments conducted to study the relationship of the areal occupation ratio to heat treatment conditions. In these experiments a Cu-Zn-Sn alloy which has composition of sample NO. 3 shown in FIG. 18 was heat-treated under conditions of different treatment temperatures (temperatures of the sample) and different lengths of temperature retaining time, and after each heat treatment, the areal occupation ratio (%) of the γ phase was determined. The cooling rate down to 400°C after the heat treatment was 0.4-5K/sec when the treatment temperature is 425°C or below, or 5-10K/sec when the treatment temperature is 450°C or below.

[0098] From FIG. 21, it can be seen that the areal occupation ratio of the γ phase becomes 3% or more when the heat treatment temperature is 550-400°C, the retaining time is 30 sec or longer, and the cooling rate is in the range of 5-10K/sec. In addition, when the heat treatment temperature exceeds 550°C, the areal occupation ratio of the γ phase does not increase but reveals the reverse tendency to decrease even if the retaining time is extended. Therefore, to increase the areal occupation ratio of the γ phase to 3% or higher, the treatment temperature has to be 550°C or below. Furthermore, in the heat treatment within the treatment temperature range of 400-500°C in FIG. 21, crystal structure of the "α+γ type" is formed, and in the heat treatment within the treatment temperature range of 450-550°C, crystal structure of the "α+β+γ type " is formed.

[0099] In the next place, the term, "fine crystal grains", is described. In all the above-mentioned examples of brass of this invention, the average crystal grain size is 15 μm or less, preferably 10 μm or less. Such fine crystal grains allow hot forging at rather lower temperature than in the cases of conventional production method, and has advantages of rather high hot ductility (in the forging temperature zone) and yield point strength (yield strength).

[0100] Different conditions of the production process contribute to microcrystallization of the crystal grains. For example, in the production process shown in FIG. 3, the following conditions can be selected for microcrystallizing the crystal grains. First, when a mixture of electrolytic copper, electrolytic zinc and scraps is melted and cast (step 1), the quantity of Zn to be mixed is adjusted so that the ratio of the α phase to the β phase in the recrystallization temperature zone can be 30-80%. It is useful for causing dynamic recrystallization during the subsequent hot extrusion or hot forging to maintain the ratio of the β phase in the above limits (the crystal grain size becomes smaller when the dynamic crystallization occurs). Then in the cooling after solidification next to the casting the metal mixture is rapidly cooled at a cooling rate of 5K/sec until the temperature of the mixture is lowered to 400°C or below, thus forming intermediate products. Such rapid cooling can microcrystallize the crystal grains. Further, it is also useful for microcrystallizing the crystal

grains to maintain the solidification rate after the casting in the range of 5×10 to 10^5K/sec, preferably in the range of 10^2 to 10^5K/sec.

[0101] Another method effective for microcrystallizing the crystal grains in the forging step is to add such elements as B, Fe, Ni, P, Co, Nb, li and Zr to the alloy. Appropriate ratios of their addition are 0.05-0.5 for B, 0.01-2.0 for Fe, 0.05-0.2 for Ni, 0.04-0.2 for P, 0.01-2.0 for Co, 0.01-0.2 for Nb, 0.01-1.0 for Ti, 0.005-0.5 for Zr. Particularly it was found that the addition of P and Fe manifests a synergistic effect.

[0102] After that, the above-mentioned formed intermediate product is heated to the temperature range of 480-650°C (preferably 480-600°C), and formed to bars or wire rods by hot extrusion in this temperature range (step 2). In the extrusion the sectional area reduction ratio is set to 90% or more (preferably 95%) to cause effective dynamic recrystallization, thus preventing oversizing of the crystal grains. In the cooling after extrusion as well, the products are rapidly cooled at a 0.4K/sec or larger rate until the temperature of the products is lowered to 400°C or below to prevent oversizing of the crystal grains. Furthermore lowering the temperature for heating the intermediate products and shortening the heating time are also effective for preventing oversizing of crystal grains.

[0103] Then the bars or wire rods are cold-extruded, annealed, pickled and cut to a predetermined size to obtain billets for forging (step 3). The billets obtained in such a way is heated to secure properties appropriate for the subsequent hot forging. To maintain the fine crystal grains, the heating temperature is kept in the range of 480-750°C, and the heating time is shortened.

[0104] Then the heated billets are set into forging dies, and hot-forged in the temperature range of 480-750°C (step 5). In this time as well, shortening the interval of time from start of heating to forging operation is effective for suppressing the oversizing of the crystal grains and keeping crystal grains fine. After the forging, the products are cooled to prepare for next pickling or shot blasting. To prevent oversizing of the crystal grains after the dynamic recrystallization in the hot forging, it is advantageous to keep the cooling rate at 0.4K/sec or more.

[0105] As described above, the microcrystallization of crystal grains is affected by the cooling rate after the casting, conditions of the extrusion, etc. First, a contribution of the cooling rate to the microcrystallization of crystal grains is described in detail with reference to FIGs. 22-25.

[0106] FIG. 22A is a microscopic photograph showing crystal structure of in-process brass produced at a cooling rate of 10K/sec after the casting. FIG. 22B is a schematic drawing prepared on the basis of FIG. 22A. FIG. 23A is a microscopic photograph in which a part of FIG. 22B is enlarged. FIG. 23B is a schematic drawing prepared on the basis of FIG. 22A. On the other hand, FIG. 24A is a microscopic photograph showing crystal structure of in-process brass produced at a cooling rate of 1.3K/sec after the casting. FIG. 24B is a schematic drawing prepared on the basis of FIG. 24A. FIG. 25A is a microscopic photograph in which a part of FIG. 24A is enlarged. FIG. 25B is a schematic drawing prepared on the basis of FIG. 25A.

[0107] As clear from these figures, the higher rate of microcrystallization can be realized by increasing the cooling rate after the casting. As shown in FIGs. 23A and 23B, for example, at the cooling rate of 19K/sec the crystal structure that has an average crystal grain size of 15 μm or less and in the whole area of which the α and β phases are mixed is obtained. On the other hand, as shown in FIGs. 25A and 25B, at the cooling rate of 1.3K/sec the crystal structure that has average crystal grain size of 15 μm or more is obtained, and besides deposition of the γ phase on the boundary between both the α phase and the β phase is observed. The average crystal grain size was determined according to the relevant JIS.. Furthermore, subsequent experiments proved that in order to reduce the average crystal grain size to 15 μm or less, the cooling rate must be 5K/sec or more.

[0108] Referring now to FIGs. 26-29, the contribution of extrusion conditions to the microcrystallization is described in detail.

[0109] FIG. 26A is a microscopic photograph showing crystal structure of a bar-shaped extrusion produced from brass composed of 58.3% by wt. of Cu, 1.9% by wt. of Sn, and the remaining percentage of Zn on the conditions of the extrusion temperature of 550°C, extrusion ratio of 50% and cooling rate of 30K/sec by forced air cooling after extrusion. FIG. 26B is a schematic drawing prepared on the basis of FIG. 26A. FIG. 27A is a microscopic photograph showing crystal structure of a forging produced from the bar-shaped extrusion by forging on the conditions of cylindrical forging form, monoaxial compression, 50% forging ratio, forging temperature of 550°C and 20K/sec cooling rate after forging. FIG. 27B is a schematic drawing prepared on the basis of FIG. 27A.

[0110] The brass shown in FIGs. 26A and 26B is a mixture of α and β phases which contains the β phase at a ratio ranging from 30% at the minimum to 80% at the maximum in the heating for forging, and in the average particle grain size of 15 μm or less, thus belonging to the "α+ reinforced β type". As shown in FIGs. 27A and 27B, further this brass does not cause any change in the crystal grain size, ratio of the α phase to the β phase, and shapes of the crystal grains, and also does not cause cracks by the forging.

[0111] FIG. 28A is a microscopic photograph showing crystal structure of a bar-shaped extrusion produced from brass composed of 58.7% by wt. of Cu, 2.3% by wt. of Sn, and the remaining percentage of Zn on the conditions of the extrusion temperature of 550°C, extrusion ratio of 50% and cooling rate of 30K/sec by forced air cooling after extrusion. FIG. 28B is a schematic drawing prepared on the basis of FIG. 28A. FIG. 29A is a microscopic photograph showing

crystal structure of a forging produced from the bar-shaped extrusion by forging on the conditions of cylindrical forging form, monoaxial compression, 50% of forging ratio, forging temperature of 550°C and cooling rate after forging of 20K/sec. FIG. 29B is a schematic drawing prepared on the basis of FIG. 29A.

[0112] The brass shown in FIG. 28 as well belongs to the "α+ reinforced β type". Particularly, this brass did not cause cracks regardless of the fact that the Sn content of this brass widely exceeded the high limit of 1% by wt. at which brass in forging had been traditionally considered to cause cracks. This is supposed to be because the crystal grains are fine.

[0113] The microcrystallization of crystal grains is effective for obtaining good hot ductility. Further it is also effective for good hot ductility that, even when the crystal structure of the brass is a mixture of the α and β phases, the ratio of the β phase is in the range of from 30% to 80%. This is considered to be for the following reason:

[0114] The hot forging and hot extrusion cause strain in the crystal structure by an external force. Microscopically this strain means that atomic arrangement in the crystal structure is in disturbed condition, i.e., atomic dislocation. When dynamic recrystallization is caused in hot working, dislocated atoms are rearranged to release or free the crystal structure from strain, and as a result good hot ductility is secured. The energy sources that cause the dynamic recrystallization are thermal energy by heating and strain by an external force. When subjected to an external force, mixed structure of the α and β phases cause dislocation in softer grains of the β phase by stress from harder grains of the α phase. If the crystal grain size of the α phase is larger, the strain in the β phase concentrates on a part (perhaps because shift of β-phase grains subjected to dislocation is prevented by larger grains of the α phase). Contrarily, If the crystal grain size of the α phase is finer, the strain in the β phase is dispersed (perhaps because β-phase grains shift by grain boundary sliding caused on the boundary between the α and β phases). Since the dispersed strain has larger whole potential energy than that of local strain, recrystallization exceeds a threshold, thereby providing good ductility for the brass.

[0115] Addition of Sn is also considered to contribute not only to improvement of the corrosion resistance of the β phase but also to acceleration of the recrystallization. the acceleration of the recrystallization improves ductility of the brass against an external force exerted at a high rate.

[0116] If the recrystallization is caused after sufficient working, the crystal grains become smaller. If oversizing of fine crystal grains produced by dynamic recrystallization is prevented by increasing the cooling rate after working, even the product formed by working can obtain satisfactory properties capable of retaining fine crystal grain size.

[0117] FIG. 30 shows preferable conditions of four types of brass of this invention concerning their final crystal structure at room temperature, crystal structure in hot working (that is, in the recrystallization zone), and composition. FIG. 31 shows typical conditions for casting brass at the first step and for obtaining the final composition shown in FIG. 30 by hot-extruding the brass after the above-mentioned casting. FIG. 32 shows typical conditions of extrusion and forging when the final composition is obtained by hot-extruding and further hot-forging the brass. FIG. 33 shows typical conditions of extrusion, forging and heat treatment when the final composition is obtained by hot-extruding, hot-forging and further heat-treating the brass. The numerical values in parentheses are particularly preferable values.

[0118] Referring now to FIGs. 30-33, the crystal structure, compositions and typical production methods of the brass according to this invention.

(1) Crystal structure at room temperature (FIG. 30)

[0119] The "α+γ type" of brass has crystal structure of α + γ type. The areal ratio of the α phase is 97-70% and that of the γ phase is 3-30%, preferably that of the α phase is 95-70% and that of the γ phase is 5-30%. The average grain size of the α phase is 15 μm or less, preferably 10 μm or less. The average grain size of the γ phase (in this case, minor axis) is 8 μm or less, preferably 5 μm. In a microscopic photograph it can be observed that on the grain boundary of the α phase a thin layer of the γ phase is formed. The Sn concentration of the γ phase is 8% by wt. or more, e.g., 14-18% in examples 1-5 shown in FIGs. 2A-2C.

[0120] The "α+β+γ type" of brass has crystal structure of α + β + γ type. The areal ratio of the α phase is 40-94% and r spective areal ratios of the β and γ phases are 3-30% For example, in examples 6-12 shown in FIGs. 2A-2C, the areal ratio of the α phase is 65-82.5%, that of the β phase is 9.8-13.4%, and that of the γ phase is 4-24%. The average grain sizes of the α and β phases are 15 μm or less, preferably 5 μm or less. The average grain size of the γ phase (in this case, minor axis) is 8 μm or less, preferably 5 μm or less. In a microscopic photograph it can be observed that a thin layer (8 μm or less in thickness) of the γ phase is formed so as to surround crystals of the β phase. The Sn concentration in the γ phase is 8% by wt. or more, e.g., 11-13.4% in examples 6-12 shown in FIGs. 2A-2C.

[0121] The "α+ normal β type" of brass has crystal structure of α + β type. For example, in examples 13-15 shown in FIGs. 2A-2C, the areal ratio of the β phase is 23.1-25.6%. The average grain sizes of the α and β phases are 15 μm or less, preferably 5 μm or less.

[0122] The "α + reinforced β type" of brass has crystal structure of α + β type. The areal ratio of the β phase is 15% or more, preferably 20% or more, and for example, 23-38% in examples 16-19 shown in FIGs. 2A-2C. The average grain sizes of the α and β phases are 15 μm or less, preferably 10 μm or less. The Sn concentration in the β phase is 1.5% by wt. or more, e.g., 2.5-7.1% by wt. in examples 16-19 shown in FIGs. 2A-2C.

(2) Crystal structure in hot working (in recrystallization temperature zone) (FIG. 30)

[0123] All the types of brass have crystal structure of α + β type, and the areal ratio of the β phase is 30-80%. The average crystal grain sizes of the α + β type are 15 μm or less, preferably 10 μm or less. The crystal grains of the α phase are substantially uniformly distributed.

(3) Composition (FIG. 30)

[0124] The α+γ type" and "α+β+γ type" of brass have apparent Zn contents of 37-46% by wt, preferably 38-46% by wt. In order to obtain good hot ductility. The overall Sn content is 0.9-7% by wt. For instance, in examples 1-5 of the " α + γ type" shown in FIGs. 2A-2C, the apparent Zn content is 37.8-44% by wt., and the overall Sn content is 1.5-3.5% by wt.

[0125] The α+ normal β type" of brass has the apparent Zn content of 37-44% by wt, preferably 38-44% by wt. In order to obtain good hot ductility. For instance, in examples 13-15 shown in FIGs. 2A-2C, the apparent Zn content is 41.8-44% by wt., and the overall Sn content is less than 0.5% by wt.

[0126] The α+ reinforced β type" of brass has the apparent Zn content of 37-44% by wt, preferably 38-44% by wt. In order to obtain good hot ductility. The overall Sn content is 0.5-7% by wt. For instance, in examples 16-19 shown in FIGs. 2A-2C, the apparent Zn content is 40.1-42.6% by wt., and the overall Sn content is less than 0.8-3.6% by wt.

(5) Casting conditions (FIG. 31)

[0127] The solidification rate at the time of casting is 5×10^1 to 10^5K/sec, preferably 10^2 to 10^5K/sec. The solidification rate of 10^5K/sec is the high limit for preventing the brass from becoming amorphous. The cooling rate down to 400°C or below after the solidification is to be 5K/sec or more.

(6) Conditions of hot extrusion in the case of obtaining final structure by hot extrusion (FIG. 31)

[0128] The extrusion temperature is 480-650°C, preferably 480-600°C. The sectional reduction ratio (sinking ratio) is 90% or more, preferably 95% or more. The cooling rate until the temperature after extrusion is lowered to 400°C or below is 0.4-5K/sec for the "α+γ type", 9.4-10K/sec for the " α+β+γ type" , 0.4° C or more for "α+ normal β type", and 5-1000K for "(α+ reinforced β type". For example, the cooling rate is 0.8K (air cooling) when in examples shown in FIGs. 2A-2C the "α+γ type" (examples 1-5), "α+β+γ type" (examples 6-12) or "(α+ normal β type" (examples 13-15) of brass is produced, and the cooling rate is 100°/sec (water cooling) when the "α+β+γ type" of brass is produced.

(7) Conditions of hot extrusion and hot forging in the case of obtaining final structure by hot forging (FIG. 32)

[0129] Conditions of the hot extrusion are the same as described in (6) above except that regardless of the type of crystal structure the cooling rate after the extrusion is to be 4°C or more until the temperature is lowered to 400°C or below.

[0130] The temperature for the hot forging is 480-750°C, and for example, 500-600°C in examples shown in FIGs. 2A-2C. The strain rate of the forging is preferably 1/sec or more.

[0131] The cooling rate after the forging is the same as the cooling rate after the extrusion described in (6) above.

(8) Conditions of hot extrusion, hot forging and heat treatment in the case of obtaining final structure by heat treatment (FIG. 33)

[0132] Conditions of the hot extrusion are the same as described in (7) above. Conditions of the hot forging are the same as described in (7) above except that regardless of the type of crystal structure the cooling rate after the forging is to be 4°C or more until the temperature is lowered to 400°C or below.

[0133] The heat treatment is not required for producing the "α+ normal β type" (that is, when the hot forging is carried out on the above-mentioned condition, the final structure of the "α+ normal β type" is obtained). The heat treatment temperature and the retaining time are 450-550 °C and 30 sec or longer for the "α+γ type", 450-550°C and 30 sec or longer for the "α+β+γ type", and 475-550 °C and 30 sec or longer for the "α+ reinforced β type". The cooling rate after the heat treatment is the same as that after the extrusion described in (6) above.

[0134] While typical embodiment of the brass of this invention and the method of production thereof has been described hereinbefore, it is to be understood that the present embodiment is illustrative and not restrictive, and therefore that the invention be not limited by any of the details of the preceding description. The principle of this invention is typically applied to brass, and also may be applied to alloys other than brass without departing from the scope of this

invention.

6. POSSIBILITY OF INDUSTRIAL APPLICATION

[0135] The α+β+γ, α+γ, α+ normal β, and α+ reinforced β types of brass can be applied to products that have been so far made up of materials other than brass for such reasons as surface roughness, corrosion resistance, dimensional accuracy in addition to applications that have traditionally used brass as seen in water-contact parts, such as valves and faucets, metals for sanitary porcelain, different pipe fittings and couplings, pipes, gas fittings, building materials such as doors and knobs, electric household appliances. As water-contact parts that can use the brass according to this invention, faucets, metal fittings for hot-water supply systems, toilet-seat hot-water washers, etc., water supply pipes, connection pipes, valves, etc. can be exemplified. The following explains some examples.

[0136] FIG. 34 illustrates an example of faucet fitting using the brass of this invention. In FIG. 34 a pressure-resistant large body subjected to water pressure on the primary side is connected with a spout 25 through a small pressure-resistant fitting 23 on the secondary side. The minimum thickness of the body 21 is 0.2 mm or more, and the minimum thickness of the fitting and spout is 0.1 mm or more. In another example portrayed in FIG. 35 a brass forging of this invention is used as an elbow pipe 29 connected to a water pipe 27. In a further example illustrated in FIG. 36 a brass forging of this invention is used as a connecting metal 33 for a shower hose A still further example shows a brass forging of this invention used for a fitting 41 in connection between pipes 35, 37 and 39.

[0137] FIGs. 38, 39, and 40 show brass parts of this invention used for a hot-water supply system. FIG. 38 is an overall sectional view of the hot-water supply system. As shown in FIG. 38, the brass of this invention is used for a pressure reducing valve 53 connected to a water inlet pipe 51, and a bypass valve connected to a water feed valve 55 for water feed from the pressure reducing valve 53. In particular, in the pressure-reducing valve 53 shown in FIG. 39, the brass of this invention is used for a valve body 61 and valve stem 63 (hatched parts), and in the bypass valve 57 shown in FIG. 40, the brass of this invention is used for a valve body 71 (a hatched part).

[0138] The brass of this invention has excellent corrosion resistance and acid resistance, and therefore when used for water-contact parts, the brass has scarce strength reduction due to secular change of the water-contact parts. The brass of this invention not only excels in corrosion resistance and acid resistance but also has high strength, and therefore it enables water contact parts to have thinner wall. In particular the JIS of faucets stipulates pressure-resistant performance of 17.5 kg/cm^2 for pressure-resistant metal parts in water contact. The wall thickness of water-contact parts has to be decided by taking decrease of the wall thickness by taking secular corrosion into consideration in connection with this pressure-resistant performance. Hitherto the minimum wall thickness of cylindrical faucet metal parts of 100 mm in diameter has been decided to be 1.0-1.5 mm. However, the brass of this invention can reduce the minimum wall thickness to 0.8-1.2 mm when used for these parts.

[0139] Furthermore the brass of this invention has good machinability, so that the machining time can be shortened, and its high hot ductility secures formability in a short time by forging etc. High forgeability in a short time increases degrees of freedom in designing. The high hot ductility and the forgeability at such low temperature as 600°C or below improve precision and profile irregularity of forgings and prevents oxide films from being formed on forged surfaces.

[0140] The α+β+γ, α+γ , α+normal β and α+reinforced β types of the brass according to this invention have very wide applications as described below, including products that have been conventionally made of brass, metals other than brass as stainless steel, and nonmetallic materials.

(1) Raw materials, intermediate products, final products, and assemblies of them

[0141] Brass alloys, intermediate products, final products and assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot. Brass, intermediate products, final products and assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, hot working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding. Brass alloys, intermediate products, final products and assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating, chemical treatment, surface hardening, nonmetallic coating and painting.

(2) Parts for transport equipment

(2-1) Automobile and bicycle parts

[0142] Transmission parts, such as synchrogears and bearings; engine parts, such as timing gears, pulleys, bearings, couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles and engine blocks; radiator parts, such as fittings; vehicle

bodies; external vehicle parts such as trims, door handles and wipers; internal vehicle parts, such as meter parts and alarm parts; driving system parts, such as tire air nozzles, axles and wheel bases; brake parts, such as joints; steering parts, such as hydraulic fittings and gears; air-conditioning parts, such as fittings; suspension parts, such as bearings; and oil-hydraulic pump parts, such as vehicle bodies, valves and pistons.

(2-2) Large and small ship parts

[0143] Engine parts, such as timing gears, pulleys, bearings, couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles and engine blocks; ship bodies; ship outfit parts, such as handrails, trims, door handles and masts; driving system parts, such as screws, propellers, and shafts; meter parts, such as casings and mechanical handles; steering parts; air-conditioning parts; and hydraulic pump parts.

(2-3) Rolling stock parts

[0144] Engine parts, such as timing gears, pulleys, bearings, couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles and engine blocks; motor parts, such as bodies, bearings and cooling fittings; transmission parts, such as synchrogears and bearings; radiator parts, such as fittings; vehicle bodies; external vehicle parts such as trims, door handles and wipers; internal vehicle parts, such as meter parts, alarm parts and handrails; driving system parts, such as tire air-nozzles, axles and wheel bases; brake parts, such as joints; steering parts, such as hydraulic fittings, gears and steering wheels; air-conditioning parts, such as fittings; suspension parts, such as bearings; hydraulic pump parts, such as vehicle bodies, valves and pistons; pantograph parts such as fittings; and overhead wire parts such as fittings.

(2-4) Airplane, spacecraft, elevator and playground vehicle parts

(3) Parts for industrial machinery

(3-1) Construction machinery parts

[0145] Engine parts, such as timing gears, pulleys, bearings, couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles and engine blocks; motor parts, such as bodies, bearings and cooling fittings; transmission parts, such as synchrogears and bearings; radiator parts, such as fittings; external vehicle parts such as trims, door handles and wipers; internal vehicle parts, such as meter parts and alarm parts; brake parts, such as joints; steering parts, such as hydraulic fittings, gears and steering wheels; air-conditioning parts, such as fittings; suspension parts, such as bearings; and hydraulic pump parts, such as vehicle bodies, valves and pistons.

(3-2) Welding machine parts

[0146] Gas welder parts, such as torches; arc welder parts, such as torches; and plasma welder parts, such as torches.

(3-3) Metal dies and their parts

(3-4) Roller conveyer parts

(3-5) Bearings and gears

(3-6) Mechanical sliding parts such as synchrorings

(3-7) Heat exchanger parts

[0147] Boiler parts, such as bodies and valves; and solar water heater parts such as bodies and valves.

(4) Parts for musical instruments

(4-1) Keyboard instruments parts

[0148] Piano parts, such as pedals and fittings; electronic piano parts, such as pedals and fittings; and organ parts, such as pedals, fittings and resonator pipes.

(4-2) Wind instrument parts

[0149] Trumpet parts such as bodies, pistons, levers and fittings; trombone parts, such as bodies, pistons, levers and fittings; tuba parts, such as bodies, pistons, levers and fittings; clarinet parts, such as bodies, pistons, levers and fittings; and bassoon parts, such as bodies, pistons, levers and fittings.

(4-4) Percussion instrument parts

[0150] Drum parts, such as holders and cymbals; kettle drum parts, such as holders and kettles; and xylophone parts, such as resonator pipes and frames.

(5) Parts for electric equipment

(5-1) Audiovisual equipment parts

[0151] Amplifiers, videoplayers, cassette players, CD players and LD players parts, such as adjuster knobs, equipment legs, equipment chassis and speaker corns.

(5-2) Gas and liquid control equipment parts

[0152] Room air-conditioning parts, such as fittings, cooling medium pipes, and valves; hot-water supply system and electric water heater parts, such as casings, water-storage vessels, gas piping, gas nozzles, gas burners, pressure reducing valves, relief valves, proportioning valves, solenoid valves and pump parts; and room heater and room cooler parts, such as carburetors, cooling medium pipes, service valves and flare nuts.

(5-3) Home-electric equipment parts

[0153] Washing machine parts, such as casings and tubs.

(5-4) Sawing machine and knitting machine parts

(5-5) Playground equipment parts

[0154] Pinball parts and slot machine parts.

(5-6) Electric outdoor equipment parts

[0155] Automatic vending machine parts, such as coin slots and coin acceptors.

(5-7) Electric and electronic circuit package parts

[0156] Control boards, printed wiring panels, switch-board electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, casings, solders, etc.

(6) Housing implements

(6-1) Building materials

[0157] External building materials, architectural fitting parts, housing wall panels, reinforcing bars, building frames, etc.

(6-1) External housing fixtures

[0158] Door parts, such as door panels, door knobs, locks, trims and hinges; gate parts, such as gate poles, gate doors, casing trims and hinges; fence parts, such as fence bodies and stiles; outdoor light parts, such as casings, lampshades and light poles; shatters; verandah fences; mailboxes; rain-water gutters; rain-water gutter strap hangers; roofs; sprinklers; and flexible tubes.

(6-2) Internal housing fixtures

[0159] Handrail parts, such as handrail pipes and joints; door parts, such as door knobs, locks, trims and hinges; kitchen utensils, such as gas cooker burners and cooker top plates; bathroom fixtures, such as perforated water-distributing port plates, drainage plugs, drainage plug chains, shower hangers and sprinkling plates; wash-room fixtures, such as counter fixing metals and towel bars; living room fixtures, such as chandelier parts, illumination parts and artistic ornaments; lavatory fixtures, such as lavatory booth external wall panels; and furniture parts, such as chair legs, table legs, table leaves, hinges, furniture handles, furniture rails and shelf adjustment screws.

(6-3) Religious implements

[0160] Handrail parts, such as handrail pipes and joints; and family altar parts, such as Buddhist statues, casing trims, candlesticks and bells.

(7) Parts for precision machinery

(7-1) Optical instrument and measurement instrument parts

[0161] Camera, telescope, microscope and electron microscope parts, such as bodies, lens mounts and lens cases.

(7-2) Clock and watch parts

[0162] Wristwatch, wall clock and table clock parts, such as bodies, watch and clock hands, gaskets, gears and clock pendulums.

(8) Writing implements and office supplies

[0163] Writing implements such as ball-point pens and mechanical pencils, and scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, etc.

(9) Plumbing implements, valves and faucets

[0164] Drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipes, joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, etc.

(10) Decorations and accessories,

[0165] Decoration and accessory parts, such as pierced earrings, pendants, finger rings, brooches, nameplates, tie-pins, tie bars, bracelets, bag metals, shoe metals, clothing metals, buttons, zipper parts, hooks and belt metals.

(11) Sports articles and weapons

[0166] Golf club parts such as shafts, heads, toes, heels and soles, and dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, etc.

(12) Cans and receptacles

[0167] Cans and receptacles for foods, drinks, fuels, paints, powders, liquids, gases, etc.

(13) Medical instruments

[0168] Bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical

operation instrument parts, therapeutic instrument parts, etc.

(14) Working tools, agricultural implements and construction tools

[0169] Pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, etc.

(15) Tableware and daily household utensils

[0170] Cooking pots and pans, rice-cooking pots, kitchen knives, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets, litter baskets, pails, washbowls, sprinkling cans, etc.

(16) Sundries, gardening implements and gadgets

[0171] Cups, replicas, lighters, character goods, medals, bells, hair pins, hot curlers, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, casters, etc.

Claims

1. A metal which comprises a crystal structure that causes strain dispersedly in metal crystals when the metal is deformed by an external force, so that strain energy due to the deformation becomes a source of recrystallization energy of the metal crystals.

2. A method for producing metal products which comprises a process that carries out hot working on a metal, when strain energy of metal crystals strained by an external force in hot working is expressed as SE and thermal energy given by heating in the hot working as TE, under the conditions of:

$$SE+TE > \text{minimum energy necessary for recrystallization of deformed metal crystals, and}$$

$$TE < \text{energy necessary for oversizing of deformed metal crystals.}$$

3. The method for producing metal products as defined in claim 1, in which the metal has such crystal structure that causes dispersedly strain of the metal crystals when deformed by an external force.

4. The metal as defined in claim 1, in which the metal has crystal structure that contains first relatively mild crystals and second relatively hard crystals which is so fine that the strain caused in the first crystals by grain boundary sliding of the first and second crystals when subjected to an external force can be dispersed.

5. The metal as defined in claim 4, in which the metal contains at least two metal elements necessary for the first crystals to be mild and the second crystals to be hard, and a third element contributing to increase of recrystallization rate exists in the form of solid solution in the first crystals.

6. The metal as defined in claim 5, in which the third element has an atomic radius similar to that of the two kinds of metal elements, so as to be solid-dissolved, as a substitute, in the first crystals.

7. The metal as defined in claim 5 or 6, in which the two types of metal crystals are copper and zinc.

8. The metal as defined in claim 7, in which the third element is Sn.

9. A metal satisfying, in a recrystallization temperature zone, one or such conditions:

that the metal does not break when given 200% strain at the strain rate of 0.1/sec; and
that the metal does not break when given 100% strain at the strain rate of 1/sec.

10. A metal which does not break when given strain that exceeds 200% at a strain rate of 0.01/sec in a recrystallization

temperature zone, and satisfies, at a room temperature at least one of three conditions:

(1) that the metal has 80% or larger cutting resistance index with reference to free-cutting brass bars according to Japanese Industrial Standard C 3604;

(2) that the metal has corrosion resistance satisfying at least either one of such conditions that when the metal is subjected to a dezinking corrosion test according to Japan Brass Makers Association's technical standard JBMA T-303 on the metal, the maximum dezinking depth is 100 μm or less when the direction or the maximum dezinking penetration depth is parallel with the working direction, and that the maximum dezinking depth is 70 μm or less when the direction of the maximum dezinking penetration depth is rectangular to the working direction; and

(3) that the metal has stress corrosion cracking (SCC) resistance satisfying such a condition that when a cylindrical sample of the metal is exposed to an ammoniacal atmosphere over a 14% ammonia water and then kept under a load, the maximum stress to which the sample is able to endure without cracking is 180 N/mm^2 or more.

11. Brass satisfying at least on of such conditions that the brass does not break when subjected to strain exceeding 200% at a strain rate of 0.01/sec in a recrystallization temperature zone, and that the brass does not break when subjected to strain exceeding 600% at a strain rate of 0.001/sec in a recrystallization temperature zone.

12. Brass having crystal structure of α+β type in the recrystallization temperature zone, which crystal structure in the recrystallization temperature zone, satisfies all of such conditions :

(A1) that areal ratio of the β phase is 30-80%,
(A2) that average crystal grain size in the α and β phases is 15 μm or smaller, preferably 10 μm or smaller; and
(A3) that the α phase exists dispersedly.

13. The brass as defined in claim 12, which has crystal structure of α+γ type at room temperature, which crystal structure satisfies at room temperature all of such conditions:

(B1) that the areal ratio of the γ phase is 3-30%, preferably 5-30%;
(B2) that the average crystal grain size in the α phase is 15 μm or smaller, preferably 10 μm or smaller; and
(B3) that the average crystal grain size (minor axis) in the γ phase is 8 μm or smaller, preferably 5 μm or smaller; and
(B4) that the γ phase exists on grain boundaries of the α phase.

14. The brass as defined in claim 12, which has crystal structure of α+γ+β type, which crystal structure satisfies at room temperature all of such conditions:

(B1) that the areal ratio of the α phase is 40-94%;
(B2) that the areal ratios of both the β and γ phases are 3-30%,
(B3) that the average crystal grain size in the α and phases is 15 μm or smaller, preferably 10 μm or smaller; and
(B4) that the average crystal grain minor-axis in the γ phase is 8 μm or smaller, preferably 5 μm or smaller.

15. The brass as defined in one of claims 13 and 14, in which the crystal structure at room temperature furthermore satisfies all of such conditions:

(B5) that the γ phase contains Sn in content of 8%, by wt. or more; and
(B6) that the γ phase surrounds the β phase.

16. Brass as defined in claim 15, in which the crystal structure at room temperature furthermore satisfies such condition:

(B7) that the thickness or the γ phase surrounding the β phase is 8 μm or less, preferably 5 μm or less.

17. The brass as defined in claim 12, in which the crystal structure at room temperature furthermore satisfies all of such

conditions:

(B1) that the, areal ratio of the β phase is 20% or more, preferably 25% or more; and
(B2) that the average crystal grain size in the α and β phases is 15 μm or smaller, preferably 10 μm or smaller.

18. The brass as defined in claim 12, in which the crystal structure at room temperature furthermore satisfies all of such conditions:

(B1) that the areal ratio of the β phase is 15% or more, preferably 20% or more; and
(B2) that the average crystal grain size in the α and β phases is 15 μm or smaller, preferably 10 μm or smaller; and
(B3) that the β phase contain Sn in content of 1.5% by wt. or more.

19. A method for producing brass, which comprises the steps of: producing brass castings by casting on the conditions:

(1) that apparent Zn content in the material composition is 37-46% by wt.;
(2) that the solidification rate at the time of casting is 5×10^{1}-10^{5}K/sec, preferably 10^{2}-10^{5}K/sec; and
(3) that the cooling rate until the temperature of the castings after solidification is lowered to 400°C or below is 5K/sec or more; and

heating the brass castings up to the recrystallization temperature.

20. The method for producing brass as defined in claim 19, which further comprises a step of producing brass extrusions by hot extrusion of the brass castings within a temperature range of 480-650°C, preferably 480-600°C.

21. The method for producing brass as defined in claim 20, which further comprises a step of cooling the brass extrusions after the hot extrusion at a cooling rate of 0.4K/sec or more until the temperature of the extrusions is lowered to 400°C or below after the hot extrusion.

22. A method for producing brass, which comprises the step of producing brass extrusions by hot extrusion of brass whose apparent Zn content is 37-46% by wt., on the conditions:

(1) that the temperature at the time of extrusion is in the range of 480-650°C, preferably 480-600°C; and
(2) that the sectional reduction ratio at the time of extrusion is 90% or more, preferably 95% or more.

23. The method for producing brass as defined in claim 23, which further comprises a first cooling step for cooling the brass extrusions after the hot extrusion at a cooling rate of 0.4K/sec or more until the temperature of the brass extrusion is lowered to 400°C or below.

24. The method for producing brass as defined in claim 23, which further comprises a step of producing brass forgings by reheating and hot-forging the brass extrusions after the first cooling step at temperature within the range of 480-750°C.

25. The method for producing brass as defined in claim 24, in which the strain rate in the hot forging is l/sec or more.

26. Th method for producing brass as defined in claim 25, which further comprises a second cooling step of cooling the brass forgings after the hot forging at a cooling rate of 0.4K/sec or more until the temperature of the forgings is lowered to 400°C or below.

27. Th method for producing brass as defined in one of claims 23 and 26, in which the Sn content of the brass is 0.9-7% by wt., and the cooling rate of at least one of the first and second cooling steps is within the range of 0.4-5K/sec until the temperature of the brass is lowered to 400°C or below.

28. The method for producing brass as defined in claim 26, in which the Sn content of the brass is 0.9-7% by wt., and which further comprises a heat treatment step that heats the brass forgings after the second cooling step, maintains the brass forgings at temperature of 400-550°C for 30 sec or longer, and then cools the brass forgings at a cooling rate of 0.4-5K/sec until the temperature of the brass forgings is lowered to 400°C or below.

29. The method for producing brass as defined in one of claims 23 and 26, in which the Sn content of the brass is 0.9-7% by wt., and the cooling rate of at least one of the first and second cooling steps is within the range of 0.4-10K/sec until the temperature of the brass is lowered to 400°C or below.

30. The method for producing brass as defined in claim 26, in which the Sn content of the brass is 0.9-7% by wt., and which further comprises a heat treatment stop that heats the brass forgings after the second cooling step, maintains the brass forgings at temperature of 450-550°C for 30 sec or longer, and then cools the brass forgings at a cooling rate of 0.4-10K/sec until the temperature of the brass forgings is lowered to 400°C or below.

31. The method for producing brass as defined in one of claims 23 and 26, in which the Sn content in the brass is 0.5-7% by wt., the apparent Zn content is 37-44% by wt., and
the cooling rate of at least one of the first and second cooling steps is within the range of 5-1000K/sec until the temperature of the brass is lowered to 400°C or below.

32. The method for producing brass as defined in claim 26, in which the Sn content in the brass is 0.5-7% by wt., the apparent Zn content is 37-44% by wt., and which further comprises a heat treatment step that heats the brass forgings after the second cooling step, maintains the brass forgings at temperature of 475-550°C for 30 sec or longer, and then cools the brass forgings at a cooling rate of at least 5-1000K/sec or higher until the temperature of the brass forgings is lowered to 400°C or below.

33. A method for producing brass which comprises the steps of:

heating and then cooling brass whose apparent Zn content is 37-46% by wt.; and
controlling at least one of heating temperature, heating retaining time and cooling rate to select the crystal structure of the brass after cooling from $\alpha+\gamma$, $\alpha+\beta$ and $\alpha+\beta+\gamma$ types.

34. The method for producing brass as defined in claim 33, in which the control step is to increase the cooling rate in the order or $\alpha+\gamma$; $\alpha+\beta+\gamma$, and $\alpha+\beta$ types under condition of the same heating temperature and the same retaining time.

35. A copper alloy, which has 80% or larger cutting resistance index with reference to free-cutting brass bars according to Japanese Industrial Standard C 3604;

36. The copper alloy as claimed in claim 35, which alloy is brass.

37. A copper alloy, which has SCC resistance that satisfies such a condition that when a cylindrical copper alloy sample is exposed to an ammoniac atmosphere over a 14% ammonia water for 24 hours under a load, the maximum stress to which the sample is able to endure without cracking is 180 N/mm^2 or more.

38. The copper alloy as defined in claim 37, in which copper alloy is brass.

39. Brass which has a cutting resistance index of 80 or more, and
has corrosion resistance satisfying at least either one of such conditions that when the brass is subjected to a dezinking corrosion test according to Japan Brass Makers Association's standard JBMA T-303 on the metal, the maximums dezinking depth is 100 μm or less when the direction of the maximum dezinking penetration depth is parallel with the working direction, and that the maximum dezinking depth is 70 μm or less when the direction of the maximum dezinking penetration depth is rectangular to the working direction.

40. The brass as defined in one of claims 36, 38 and 39, in which the average crystal grain size is 15 μm or smaller, preferably 10 μm or smaller.

41. The brass as defined in claim 40, which has an α phase and a part that exists on the grain boundary of the α phase and is softer than the α phase.

42. The brass as defined in claim 41, in which the softer part than the α phase comprises Pb or Bi.

43. The brass as defined in claim 40, which has an α phase and a part that exists on the grain boundary of the α phase and is harder than the α phase.

44. The brass as defined in claim 43, in which the harder part than the α phase is a crystal.

45. The brass as defined in claim 44, in which the harder part than the α phase is a γ phase.

46. The brass as defined in claim 45, in which the γ phase contains 8% by wt. or more of Sn.

47. The brass as defined in claim 43, in which the harder part than the α phase is an intermetallic compound.

48. The brass as defined in claim 40, which has a β phase that contains a third element for improving corrosion resistance.

49. The brass as defined in claim 48, in which the β phase contains Sn in a quantity or 1.5% by wt. or more.

50. The brass as defined in claim 40, which has a β phase and a part which surrounds the β phase and has more excellent corrosion resistance than that of the β phase.

51. The brass as defined in claim 50, in which the part having more excellent corrosion resistance than that of the β phase is crystalline.

52. The brass as defined in claim 51, in which the part having more excellent corrosion resistance than that of the β phase is a γ phase that contains Sn in a quantity of 8% or more.

53. The brass as defined in claim 40, which has a γ phase that contains an element for improving corrosion resistance.

54. The brass as defined in claim 53, in which the γ phase contains Sn in a quantity of 8% by wt. or more.

55. The brass as defined in one of claims 53 and 54 , in which the γ phase exists on the boundary of another crystal phase of larger grain size than that of the γ phase and the average crystal grain minor-axis in the γ phase is 8 μm or smaller.

56. The brass as defined in one of claims 53, 54 and 55, in which the thickness of the γ phase surrounding the β phase is 8 μm or less.

57. The brass as defined in one of claims 40 to 56, which is applied to water piping parts.

58. Brass having crystal structure of α+γ types at room temperature, which crystal structure at room temperature satisfies all of much conditions:

(1) that the areal ratio of the γ phase is 3-30%, preferably 5-30%;
(2) that the average crystal grain size of the α phase is 15 μm or less, preferably 10 μm or less;
(3) that the average crystal grain size of the γ phase is 8 μm or less, preferably 5 μm or less;
(4) that the γ phase exists on the grain boundary of the α phase; and
(5) that the Sn concentration in the γ phase is 8% by wt. or more.

59. Brass having crystal structure of α+β+γ type at room temperature, which crystal structure at room temperature satisfies all of such conditions:

(1) that the areal ratios of both the γ and β phases are 3% or more;
(2) that the average crystal grain sizes of the α and β phases are 15 μm or less, preferably 10 μm or less;
(3) that the average crystal grain size of the γ phase is 8 μm or less, preferably 5 μm or less;
(4) that the γ phase surrounds the β phase; and
(5) that the Sn concentration in the γ phase is 8% by wt. or more.

60. Brass having crystal structure of α+β type at room temperature, which crystal structure at room temperature satisfies all of such conditions:

(1) that the areal ratio of the β phases are 20%, preferably 25%; and
(2) that the average crystal grain sizes of the α and β phased are 15 μm or less, preferably 10 μm or less.

61. Brass having crystal structure of $\alpha+\beta$ type at room temperature, which crystal structure at room temperature satisfies all of such conditions:

(1) that the areal ratio of the β phase is 15% or more, preferably 20% or more;
(2) that the average crystal grain sizes of the α and β phases are 15 μm or less, preferably 10 μm or less; and
(3) that the Sn concentration in the β phase is 1.5% by wt. or more.

62. A method for producing brass, which comprises a step of producing brass castings by casting on the conditions:

(1) that apparent Zn content in the material composition is 37-46% by wt.;
(2) that the solidification rate at the time of casting is 5×10^{1}-10^{5}K/sec, preferably 10^{2}-10^{5}K/sec; and
(3) that the cooling rate until the temperature of the castings after solidification is lowered to 400°C or below is 5K/sec or more.

63. A method for producing brass, which comprises the step of producing brass extrusions by hot extrusion of brass in which Sn concentration is 0.5-7% by wt. and apparent Zn content is 37-46% by wt., on the condition:

(1) that the temperature at the time of extrusion is in the range of 480-650°C, preferably 480-600°C; and
(2) that the sectional reduction ratio at the time of extrusion is 90% or more, preferably 95% or more.

64. The method for producing brass as defined in claim 63, which further comprises a first cooling step for cooling the brass extrusions after the hot extrusion at a cooling rate of 0.4K/sec or more until the temperature of the brass extrusion is lowered to 400°C or below.

65. The method for producing brass as defined in claim 64, which further comprises a step of producing brass forgings by reheating and hot-forging the brass extrusions after the first cooling step at temperature within the range of 480-750°C and at a strain rate of 1/sec or more.

66. The method for producing brass as defined in claim 65, which further comprises a second cooling step of cooling the brass forgings after the hot forging at a cooling rate of 0.4K/sec or more until the temperature of the forgings is lowered to 400°C or below.

67. The method for producing brass as defined in one of claims 64 and 66, in which the Sn content of the brass is 0.9-7% by wt., and the cooling rate of at least one of the first and second cooling steps is within the range of 0.4-10K/sec until the temperature of the brass is lowered to 400°C or below.

68. The method for producing brass as defined in claim 66, in which the Sn content of the brass is 0.5-7% by wt., and which further comprises a heat treatment step that heats the brass forgings after the second cooling step, maintains the brass forgings at temperature of 475-550°C for 30 sec or longer, and then cools the brass forgings at a cooling rate of 5-1000K/sec until the temperature of the brass forgings is lowered to 400°C or below.

69. A metal product produced from a metal which comprises crystal structure that causes metal crystals to strain dispersedly when the metal is deformed by an external force.

70. The metal product as defined in claim 69, which comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

71. The metal product as claimed in claim 69, which comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

72. The metal product as claimed in claim 69, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking cots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

73. A metal product comprising a metal satisfying one of such conditions:

that the metal does not break when given 200% strain at the strain rate of 0.1/sec; and that the metal does not break when given 100% strain at the strain rate of 1/sec.

74. The metal product as defined in claim 73, which comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

75. The metal product as claimed in claim 73, which comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

76. The metal product as claimed in claim 73, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers,

branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

77. A metal product comprising a metal which does not break when given strain that exceeds 200% at a strain rate of 0.01/sec in a recrystallization temperature zone, and satisfies, at a room temperature at least one of three conditions:

(1) that the metal has 80% or larger cutting resistance index with reference to free-cutting brass bars according to Japanese Industrial Standard C 3604;

(2) that the metal has corrosion resistance satisfying at least either one of such conditions that when the metal is subjected to a dezinking corrosion test according to Japan Brass Makers Association's standard JBMA T-303 on the metal, the maximum dezinking depth is 100 μm or less when the direction of the maximum dezinking penetration depth is parallel with the working direction, and that the maximum dezinking depth is 70 μm or less when the direction of the maximum dezinking penetration depth is rectangular to the working direction; and

(3) that the metal has stress corrosion cracking (SCC) resistance satisfying such a condition that when a cylindrical sample of the metal is exposed to an ammoniacal atmosphere over a 14% ammonia water and then kept under a load, the maximum stress to which the sample is able to endure without cracking is 180 N/mm2 or more.

---

78. The metal product as defined in claim 77, which comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

79. The metal product as claimed in claim 77, which comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans,

receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

80. The metal product as claimed in claim 77, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

81. A metal product comprising brass satisfying one of such conditions:

that the metal does not break when given 200% strain at the strain rate of 0.01/sec; and
that the metal does not break when given 600% or more strain at the strain rate of 0.001/sec.

82. The metal product as defined in claim 81, which is selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

83. The metal product as claimed in claim 81, which comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

84. The metal product as claimed in claim 81, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames,

surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns; cash boxes, and casters.

85. A metal product comprising brass having crystal structure of $\alpha+\beta$ type in the recrystallization temperature zone, which crystal structure in the recrystallization temperature zone satisfies all of such conditions:

(A1) areal ratio of the β phase is 30-80%,
(A2) average crystal grain size in the α and β phases is 15 μm or smaller, preferably 10 μm or smaller; and
(A3) the α phase exists dispersedly.

86. The metal product as defined in claim 85, which comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

87. The metal product as claimed in claim 85, which comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

88. The metal product as claimed in claim 85, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switch-

board electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rain-water gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sail-boat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

89. A metal product comprising a copper alloy which has 80% or larger cutting resistance index with reference to free-cutting brass bars according to Japanese Industrial Standard C 3604, and has 0.2% yield strength or yield stress of 300 N/mm^2 or more.

---

90. The metal product as defined in claim 89, which comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging; extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

91. The metal product as claimed in claim 90, which comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans,

receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

92. The metal product as claimed in claim 73, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

93. A metal alloy comprising copper alloy which has SCC resistance that satisfies such a condition that when a cylindrical copper alloy sample is exposed to an ammoniac atmosphere over a 14% ammonia water for 24 hours under a load, the maximum stress to which the sample is able to endure without cracking is 180 N/mm^2 or more.

94. The metal product as defined in claim 93, which comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with

other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

95. The metal product as claimed in claim 93, which comprises either on selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

96. The metal product as claimed in claim 93, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation

instrument parts, therapeutic instrument parts, pliers, hammers; measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

97. A metal product comprising brass which has a cutting resistance index of 80 or more, and has corrosion resistance satisfying at least either one of such conditions that when the brass is subjected to a dezinking corrosion test according to Japan Brass Makers Association's standard JBMA T-303 on the metal, the maximum dezinking depth is 100 μm or less when the direction of the maximum dezinking penetration depth is parallel with the working direction, and that the maximum dezinking depth is 70 μm or less when the direction of the maximum dezinking penetration depth is rectangular to the working direction.

98. The metal product as defined in claim 97, which comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

99. The metal product as claimed in claim 97, which comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

100. The metal product as claimed in claim 97, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge

electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rain-water gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sail-boat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

101. A metal product comprising brass having crystal structure of $\alpha+\gamma$ type at room temperature, which crystal structure at room temperature satisfies all of such conditions:

(1) that the areal ratio of the γ phase is 3-30%, preferably 5-30%;
(2) that the average crystal grain size of the α phase is 15 μm or less, preferably 10 μm or less;
(3) that the average crystal grain size of the γ phase is 8 μm or less, preferably 5 μm or less;
(4) that the γ phase exists on the grain boundary of the α phase; and
(5) that the Sn concentration in the γ phase is 8% by wt. or more.

102. The metal product as defined in claim 101, which comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

103. The metal product as claimed in claim 101, which comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, play-

ground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

104. The metal product as claimed in claim 101, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

105. A metal product which comprises brass having crystal structure of $\alpha+\beta+\gamma$ type at room temperature, which crystal structure at room temperature satisfies all of such conditions:

(1) that the areal ratios of both the γ and β phases are 3% or more;
(2) that the average crystal grain sizes of the α and β phases are 15 μm or less, preferably 10 μm or less;

(3) that the average crystal grain size of the γ phase is 8 μm or less, preferably 5 μm or less;
(4) that the γ phase surrounds the β phase; and
(5) that the Sn concentration in the γ phase is 8% by wt. or more.

106. The metal product as defined in claim 105, which comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

107. The metal product as claimed in claim 105, which comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

108. The metal product as claimed in claim 105, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet

joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

109. A metal product which comprises brass having crystal structure of $\alpha+\beta$ type at room temperature, which crystal structure at room temperature satisfies all of such conditions:

(1) that the areal ratio of the β phases are 20%, preferably 25%; and
(2) that the average crystal grain sizes of the α and β phases are 15 μm or less, preferably 10 μm or less;

110. The metal product as defined in claim 109, which comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

111. The metal product as claimed in claim 109, which comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

112. The metal product as claimed in claim 109, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts,

heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

113. A metal product which comprises brass having crystal structure of $\alpha+\beta$ type at room temperature, which crystal structure at room temperature satisfies all of such conditions:

(1) that the areal ratio of the β phases are 15% or more, preferably 20% or more;
(2) that the average crystal grain sizes of the α and β phases are 15 μm or less, preferably 10 μm or less; and
(3) that the Sn concentration in the β phase is 1.5% by wt. or more.

114. The metal product as defined in claim 113, which comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

115. The metal product as claimed in claim 113, which comprises either one selected from, or a component part of one

selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

116. The metal product as claimed in claim 113, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

117. A method for producing metal products which comprises a process that carries out hot working on a metal, when strain energy of metal crystals strained by an external force in hot working is expressed as SE and thermal energy given by heating in the hot working as TE, under the conditions of:

SE+TE > minimum energy necessary for recrystallization of deformed metal crystals, and

TE < energy necessary for oversizing of deformed metal crystals.

118. The metal product as defined in claim 117, which comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

119. The metal product as claimed in claim 117, which comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

120. The metal product as claimed in claim 117, which comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock

parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

121. A method for producing a brass product, which comprises the steps of:
producing brass castings by casting on the conditions:

(1) that apparent Zn content in the material composition is 37-46% by wt.;
(2) that the solidification rate at the time of casting is 5×10^{1}-10^{5}K/sec, preferably 10^{2}-10^{5}K/sec; and
(3) that the cooling rate until the temperature of the castings after solidification is lowered to 400°C or below is 5K/sec or more; and

heating the brass castings up to the recrystallization temperature.

122. The production method as defined in claim 121, in which the brass product comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

123. The production method as claimed in claim 121, in which the brass product comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

124. The production method as claimed in claim 121, in which the brass product comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instruments pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

125. A method for producing brass, which comprises the step of producing brass extrusions by hot extrusion of brass whose apparent Zn content is 37-46% by wt., on the conditions:

(1) that the temperature at the time of extrusion is in the range of 480-650°C, preferably 480-600°C; and
(2) that the sectional reduction ratio at the time of extrusion is 90% or more, preferably 95% or more.

126. The production method as defined in claim 125, in which the brass product is selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with

other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

127. The production method as claimed in claim 125, in which the brass product comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

128. The production method as claimed in claim 125, in which the brass product comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets; bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames,

surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

129. A method for producing a brass product which comprises the steps of:

heating and then cooling brass whose apparent Zn content is 37-46% by wt.; and
controlling at least one of heating temperature, heating retaining time and cooling rate to select the crystal structure of the brass after cooling from $\alpha+\gamma$, $\alpha+\beta$ and $\alpha+\beta+\gamma$ types.

130. The production method as defined in claim 129, in which the brass product comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

131. The production method as claimed in claim 129, in which the brass product comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

132. The production method as claimed in claim 129, in which the brass product comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts,

automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

133. A method for producing a brass product, which comprises a step of producing brass castings by casting on the conditions:

(1) that apparent Zn content in the material composition is 37-46% by wt.,
(2) that the solidification rate at the time of casting is 5×10^{1}-10^{5}K/sec, preferably 10^{2}-10^{5}K/sec; and
(3) that the cooling rate until the temperature of the castings after solidification is lowered to 400°C or below is 5K/sec or more.

134. The production method as defined in claim 133, in which the brass product comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

135. The production method as claimed in claim 133, in which the brass product comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat

exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

136. The production method as claimed in claim 133, in which the brass product comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sailboat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needl-s, pruning shears, gardening poles, gardening frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

137. A method for producing a brass product, which comprises the step of producing brass extrusions by hot extrusion of brass in which Sn concentration is 0.6-7% by wt. and apparent Zn content is 37-46% by wt., on the condition:

(1) that the temperature at the time of extrusion is in the range of 480-650°C, preferably 480-600°C; and
(2) that the sectional reduction ratio at the time of extrusion is 90% or more, preferably 95% or more.

138. The production method as defined in claim 137, in which the brass product comprises one selected from the groups of:

metals, intermediate products, final products, assemblies of them, and composite products combined with other materials in one of the forms of a plate, pipe, bar, wire rod and ingot;
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are worked by any working of welding, fusion welding, soldering, bonding, heat cutting, heat working, forging, extrusion, drawing, rolling, shearing, plate forming, roll forming, form rolling, spinning, bending, leveling, high-energy rate working, powder working, cutting and grinding; and
metals, intermediate products, final products, assemblies of them, and composite products combined with other materials, which are surface-treated by any working of metal coating treatment, chemical treatment, surface hardening, nonmetallic coating and painting.

139. The production method as claimed in claim 137, in which the brass product comprises either one selected from, or a component part of one selected from the group of:

automobiles, bicycles, large and small ships, rolling stock, airplanes, spacecrafts, elevators, playground vehicles, transport equipment, construction machinery, welding machines, metal dies, roller conveyors, heat exchangers, industrial machinery, keyboard instruments, wind instruments, percussion instruments, audiovisual equipment, gas and liquid controllers, home-electric equipment, sawing machines, knitting machines, playground equipment, electric outdoor equipment, electric indoor equipment, electric and electronic circuit packages, housing implements, building materials, external and internal housing fixtures, religious implements, precision machinery, optical instruments, measurement instruments, clocks and watches, writing implements, plumbing implements, valves, faucets, decorations, accessories, sports articles, weapons, cans, receptacles, medical instruments, working tools, agricultural implements, construction tools, tableware, daily household utensils, groceries, daily sundries, gardening implements, and gadgets.

140. The production method as claimed in claim 137, in which the brass product comprises one selected from the group of:

transmission parts, engine parts, radiator parts, vehicle bodies, external and internal vehicle parts, driving system parts, brake parts, steering parts, air-conditioning parts, suspension parts, oil-hydraulic pump parts, ship outfit parts, instrument parts, gears, bearings, pulley, power couplings, fuel pipes, exhaust pipes, gaskets, fuel nozzles, engine blocks, machine casings, moles, door handles, wipers, meter parts, alarm parts, air nozzles, axles, wheel bases, valves, pistons, masts, screws, propellers, fans, mechanical handles, gas welder parts, arc welder parts, plasma welder parts, welding torches, torches, metal dies, bearings, mechanical sliding parts, heat exchanger parts, boiler parts, solar water heater parts, musical-instrument pedals, resonator pipes, musical-instrument levers and frames, kettle-drums, cymbals, audio amplifier parts, videoplayer parts, cassette player parts, CD player parts, LD player parts, adjuster knobs, equipment legs, equipment chassis, speaker corns, hot-water supply system parts, electric water heater parts, pressure-reducing valves, relief valves, room heater parts, carburetors, room cooler parts, cooling medium pipes, service valves, flare nuts, oil storage vessels, gas piping, gas nozzles, burners, pump parts, washing machine parts, pinball parts, slot machine parts, automatic vending machine parts, coin slots, coin acceptors, control board parts, printed wiring parts, switchboard electrodes, switch parts, resistor parts, power plug parts, light bulb bases, lamp holder parts, discharge electrodes, water-immersed electrodes, copper wires, battery terminals, solders, architectural fitting parts, housing wall panels, reinforcing bars, building frames, door panels, door knobs, locks, hinges, gate poles, gate doors, fences, outdoor lampshade, outdoor light poles, shutters, mailboxes, sprinklers, flexible tubes, rainwater gutters, roofs, handrails, cooker top plates,, gas cooker burners, perforated water-distributing port plates, drainage plugs, door chains, hangers, sprinkling plates, fixing metals, towel bars, chandelier parts, illumination parts, artistic ornaments, chair legs, table legs, table leaves, furniture handles, furniture rails, shelf adjustment screws, family altar parts, Buddhist statues, candlesticks, bells, camera parts, telescope parts, microscope parts, electron microscope parts, lens mounts, lens holders, wristwatch parts, wall clock parts, table clock parts, watch and clock hands, clock pendulums, parts of ball-point pens, mechanical pencil parts, scissors, cutters, binders, paper clips, drawing pins, scales, rulers, templates, magnets, document trays, telephone table parts, book ends, boring machine parts, stapler parts, pencil sharpener parts, cabinets, drain plugs, rigid PVC

pipe joints, drainage ditches, elbow pipe joints, flexible joint bellows, water supply/drainage cocks, water closet joint flanges, pierced earrings, stems, spindles, ball valves, balls, sheet rings, gasket nuts, KCP joints, headers, branching cocks, flexible hoses, hose nipples, faucet bodies, faucet metal fittings, valve bodies, ball taps, stop cocks, single-function faucets, faucets with thermostat, two-valve wall faucets, skid-mounted two-valve faucets, spouts, UB elbows, mixing valves, pendants, finger rings, brooches, nameplates, tiepins, tie bars, bracelets, bag metals, clothing metals, buttons, zipper parts, hooks, belt metals, golf club parts, dumbbells, barbells, sail-boat frames, trampoline frames, starting blocks, face guards for kendo, skate blades, ski edges, ski bindings, diving parts, sport gymnasium machines and equipment, bicycle chains, tent fixtures, pistol parts, rifle parts, matchlock parts, sword parts, bullets, fuel cans, paint cans, powder cans, liquid cans, gas cans, bed frames, surgical knives, endoscope parts, dental instrument parts, diagnostic instrument parts, medical operation instrument parts, therapeutic instrument parts, pliers, hammers, measures, gimlets, files, saws, nails, chisels, planes, drills, fixing tools, clams, whetstone bases, screws, bolts, nuts, machine screws, hoes, axes, shovels, cooking pots and pans, rice-cooking pots, frying pans, ladles, spoons, forks, knives, can openers, corkscrews, frying turners, frying chopsticks, hot plates, kitchen strainers, scrubbing brushes, wastebaskets. litter baskets, pails, washbowls, sprinkling cans, cups, replicas, lighters, character goods, medals, bells, hair pins, hot curler, ashtrays, flower vases, keys, coins, fishing tackles, lures, glasses frames, nail clippers, pinball balls, insect baskets, umbrellas, needle point holders (frogs), needles, pruning shears, gardening poles, gardening, frames, gardening trellises, flower baskets, thimbles, garden lanterns, cash boxes, and casters.

141. A system for producing metal products which comprises a process that carries out hot working on a metal, when strain energy of metal crystals strained by an external force in hot working is expressed as SE and thermal energy given by heating in the hot working as TE, under the conditions of:

$$SE+TE > \text{minimum energy necessary for recrystallization of deformed metal crystals, and}$$

$$TE < \text{energy necessary for oversizing of deformed metal crystals.}$$

142. A system for producing a brass product, which comprises casting equipment configured or coordinated so as to produce brass castings by casting on the conditions:

(1) that apparent Zn content in the material composition is 37-46% by wt.;
(2) that the solidification rate at the time of casting is 5×10^{1}-10^{5}K/sec, preferably 10^{2}-10^{5}K/sec; and,
(3) that the cooling rate until the temperature of the castings after solidification is lowered to 400°C or below is 5K/sec or more.

143. The production system as defined in claim 142, which further comprises equipment that heats the brass casting up to the recrystallization temperature.

144. The production system as defined in claim 142, which further comprises equipment that produces brass extrusions by hot extrusion of the brass castings within a temperature range of 480-650°C, preferable 480-600°C.

145. The production system as defined in claim 144, which further comprises equipment that cools the brass extrusions after the hot extrusion at a cooling rate of 0.4K/sec or more until the temperature of the extrusions is lowered to 400°C or below after the hot extrusion.

146. A system for producing brass, which comprises extrusion equipment that is capable of accepting brass whose apparent Zn content is 37-46% by wt., and produces brass extrusions by hot extrusion on the conditions:

(1) that the temperature at the time of extrusion is in the range of 480-650°C, preferably 480-600°C; and
(2) that the sectional reduction ratio at the time of extrusion is 90% or more, preferably 95% or more.

147. The production system as defined in claim 146, which further, comprises equipment for cooling the brass extrusions after the hot extrusion at a cooling rate of 0.4K/sec or more until the temperature of the brass extrusion is lowered, to 400°C or below.

148. A system for producing brass, which comprises equipment, that is capable of accepting brass whose apparent Zn content is 37-40% by wt. and producing brass forgings by heating and hot-forging the brass extrusions at a temperature within the range of 480-750°C.

149. The production system as defined in claim 148, in which the strain rate in the hot forging is 1/sec or more.

150. The production system as defined in claim 148, which further comprises equipment for cooling the brass forgings after the hot forging at a cooling rate of 0.4K/sec or more until the temperature of the forgings is lowered to 400°C or below.

151. The production system as defined in claim 150, which further comprises heat treating equipment that heats the brass forgings after the cooling, maintains the brass forgings at temperature of 400-550°C for 30 sec or longer, and then cools the brass forgings at a cooling rate of 0.4-5K/sec until the temperature of the brass forgings is lowered to 400°C or below.

152. The production system as defined in claim 150, which further comprises heat treating equipment that heats the brass forgings after the cooling, maintains the brass forgings at temperature of 400-550°C for 30 sec or longer, and then cools the brass forgings at a cooling rate of 0.4-10K/sec until the temperature of the brass forgings is lowered to 400°C or below.

153. The production system as defined in claim 150, which further comprises heat treating equipment that heats the brass forgings after the cooling, maintains the brass forgings at temperature of 475-550°C for 30 sec or longer, and then cools the brass forgings at a cooling rate of 5-1000K/sec until the temperature of the brass forgings is lowered to 400°C or below.

154. A system for producing brass which is capable of accepting brass whose apparent Zn content is 37-46% by wt., and
which comprises a mechanism that heats and then cools the brass, and at least one of heating temperature, heating retaining time and cooling rate of which is adjusted to make the crystal structure of the brass after cooling any one of the $\alpha+\gamma$, $\alpha+\beta$ and $\alpha+\beta+\gamma$ types.

	Corrosion Resistance	Yield Strength	Forgeability (Hot)	Forgeability (Cold)	Machinability	Cold Ductility	Remark
α phase	○	△	△	◎	×	◎	Physical properties closely resemble those of Cu.
β phase	×	○	◎	×	◎	△	Physical properties closely resemble those of Zu.
β phase + Sn	○ Noticeably improved	◎ App. 30% improved	◎	×	◎	△	
γ phase	◎	◎	○	×	○	×	
Pure Cu	Good	×	△	◎	×	◎	
Pure Zn	Poor	○	×	×	◎	△	
Pure Sn	Good	○	×	×	○	×	

Fig. 1

	Heat Treatment Conditions		Composition								
	Temperature	Cooling	Cu (%)	Pb (%)	Fe (%)	Sn (%)	P (%)	Ni (%)	Sb (%)	Zn (%)	Zn Equivalent (%)
Reference 1	500	Air cooling	61.3	2.0	—	0.3	0.08	0.05	0.03	36.2	38.50
Reference 2	500	Air cooling	60.8	2.4	0.2	0.5	0.10			36.0	39.00
Example 1	500	Air cooling	62.9	1.5	—	1.0	0.05	0.05	0.03	34.5	37.80
Example 2	500	Air cooling	61.3	2.0	—	1.0	0.08	0.05	0.03	35.5	39.20
Example 3	500	Air cooling	60.8	2.4	0.2	1.5	0.10	—	—	35.0	40.00
Example 4	500	Air cooling	59.6	1.8	0.1	3.0	0.05	—	—	35.5	42.10
Example 5	500	Air cooling	60.8	2.0	0.1	5.0	0.05	—	—	32.1	44.00
Reference 3	600	Air cooling	61.8	2.2	0.4	1.0	—	—	—	34.6	39.20
Example 6	600	Air cooling	60.0	2.0	0.3	1.5	—	—	—	36.2	41.50
Example 7	600	Air cooling	60.0	2.0	0.3	2.0	—	—	—	35.7	42.00
Example 8	600	Air cooling	59.0	2.0	0.3	1.5	—	—	—	37.2	42.50
Example 9	600	Air cooling	59.0	2.0	0.3	2.0	—	—	—	36.7	43.00
Example 10	600	Air cooling	58.0	2.0	0.3	2.0	—	—	—	37.7	44.00
Example 11	600	Air cooling	59.0	2.0	0.3	2.5	—	—	—	36.2	43.50
Example 12	600	Air cooling	59.0	2.0	0.3	3.0	—	—	—	35.7	44.00
Reference 4	550	Air cooling	59.0	2.8	0.2	0.5	—	—	—	37.5	41.50
Example 13	550	Air cooling	58.4	3.0	0.2	0.2	—	—	—	38.2	41.80
Example 14	550	Air cooling	58.1	3.0	0.2	0.3	—	—	—	38.5	42.10
Example 15	550	Air cooling	58.2	3.2	0.2	0.3	—	—	—	38.1	42.00
Reference 5	600	Water cooling	58.9	2.0	—	0.4	0.08	0.05	0.03	38.5	41.30
Example 16	600	Water cooling	60.6	1.5	—	0.8	0.05	0.05	0.03	37.0	40.10
Example 17	600	Water cooling	59.3	2.0	—	1.5	0.08	0.05	0.03	37.0	42.00
Example 18	600	Water cooling	59.3	2.4	0.2	2.0	0.10	—	—	36.0	42.60
Example 19	600	Water cooling	62.2	1.8	0.2	3.8	0.05	—	—	32.0	41.60

Fig. 2A

	γ Phase		β Phase			α Phase		
	Areal Occupancy (%)	Sn Concentration (%)	Areal Occupancy (%)	Sn Concentration (%)	Grain Size (μm)	Areal Occupancy (%)	Sn Concentration (%)	Grain Size (μm)
Reference 1	1.0	11.0				98.0	0.19	20.1
Reference 2	2.0	13.0				97.0	0.25	21.5
Example 1	3.2	14.5				95.8	0.56	14.5
Example 2	3.5	14.0				95.5	0.53	14.3
Example 3	7.0	14.0				92.0	0.57	14.4
Example 4	13.0	15.8				86.0	1.10	9.5
Example 5	21.0	18.0				78.0	1.56	9.3
Reference 3	2	10	2	1.70	4	95.0	0.90	30.0
Example 6	4.5	11.6	12	2.05	8	82.5	0.68	10.0
Example 7	9	11.3	13	2.01	6	77.0	0.75	9.8
Example 8	5	10.9	16	2.13	8	78.0	0.72	9.5
Example 9	10	11.0	10	2.14	6	79.0	0.74	9.7
Example 10	10	9.8	24	1.87	10	65.0	0.70	8.9
Example 11	15	11.0	8	1.80	6	76.0	0.86	9.2
Example 12	16	13.4	4	1.80	4	79.0	1.10	9.5
Reference 4		—	17			82.0	0.5	19.0
Example 13		—	25.6			73.4	0.2	7.6
Example 14		—	23.1			75.9	0.3	10.1
Example 15		—	25.2			73.8	0.3	5.7
Reference 5			19.0	1.30		80.0	0.19	22.0
Example 16			23.0	2.50		76.0	0.30	9.5
Example 17			25.0	3.10		74.0	0.98	9.7
Example 18			29.0	3.50		70.0	1.41	10.5
Example 19			38.0	7.10		61.0	1.81	10.2

Fig. 2B

	Yield $\sigma_{0.2}$ (N/mm²)		Cold Ductility (%)	Hardness (Hv)	Hot Ductility	Machining Resistance Index	Corrosion Resistance	Erosion Resistance	SCC Resistance
Reference 1	265	×	35.2	91	○	×	○	×	×
Reference 2	273	×	34.8	93	○	×	○	×	×
Example 1	308	○	25.3	102	×	×	○	○	○
Example 2	314	○	23.8	105	○	×	○	○	○
Example 3	355	◎	21.7	112	○	○	○	○	○
Example 4	365	◎	18.7	113	○	○	○	○	○
Example 5	378	◎	13.2	150	○	○	○	○	○
Reference 3	291	×	39.8	93	○	×	○	×	×
Example 6	330	○	16.9	122	○	○	○	○	○
Example 7	352	◎	17.0	133	○	○	○	○	○
Example 8	356	◎	13.4	126	○	○	○	○	○
Example 9	352	◎	13.0	133	○	○	○	○	○
Example 10	372	◎	11.5	147	○	○	○	○	○
Example 11	350	◎	12.3	142	○	○	○	○	○
Example 12	362	◎	10.4	142	○	○	○	○	○
Reference 4	193	×	22.0	115	○	×	×	×	×
Example 13	369	◎	21.0	143	○	○	×	×	○
Example 14	342	○	27.0	126	○	○	×	×	○
Example 15	366	◎	22.6	155	○	○	×	×	○
Reference 5	250	×	21.0	95	○	○	×	×	×
Example 16	355	◎	25.2	120	○	○	○	○	○
Example 17	372	◎	21.6	121	○	○	○	○	○
Example 18	358	◎	20.8	124	○	○	○	○	○
Example 19	380	◎	18.2	130	○	○	○	○	○

Fig. 2C

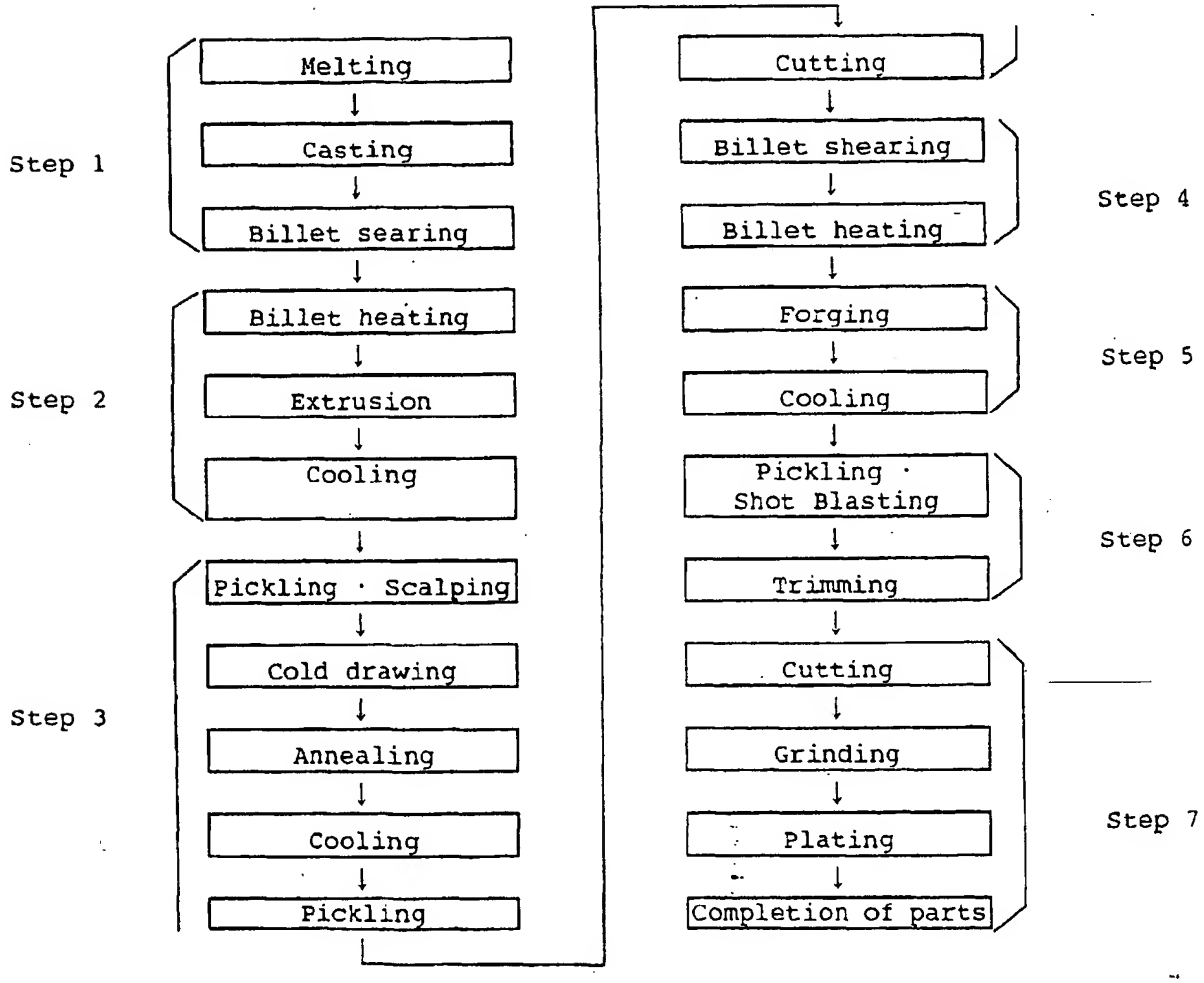


Fig. 3

	Apparent Zn Content	Solidification Rate at Casting	Cooling Rate after Casting	ExtrusionTemperature	Cooling after Extrusion
Method 1 of this invention	41.5 – 46.0	$5 \times 10 - 10^{3}$K/sec	5K/sec or higher until temp. lowers below 400℃	480 – 550℃	0.4K/sec or more by air cooling
Method 2 of this invention	38.0 – 43.5	$5 \times 10 - 10^{3}$K/sec	5K/sec or higher until temp. lowers below 400℃	550 – 625℃	0.4K/sec or more by air cooling
Conventional method	39.0 – 43.0	3×10K/sec	5K/sec or higher until temp. lowers below 400℃	650 – 750℃	0.3K/sec or below by air cooling

Fig. 4

	Grain Size	β-phase Ratio at Forging	Forging Temperature	Strain and Straining Rate in Forging Temp. Zone	Yield Strength $\sigma_{0.2}$	After Forging		
						α-phase Ratio	β-phase Ratio	γ-phase Ratio
Method 1 of this invention	10 μ m	50 - 80%	480 – 550℃	200% $\varepsilon = 10^{0}$ sec^{-1}	350 N/mm^2	20 - 60%	80 – 10%	0 – 30%
Method 2 of this invention	15 μ m	30 – 60%	550 – 625℃	100% $\varepsilon = 10^{0}$ sec^{-1}	300 N/mm^2	30 – 70%	70 – 0%	0 – 30%
Conventional method	>20 μ m	60 – 80%	650 – 750℃	60% $\varepsilon = 3 \times 10^{-1}$ sec^{-1}	100 N/mm^2	20 – 70%	80 – 30%	0%

Fig. 5

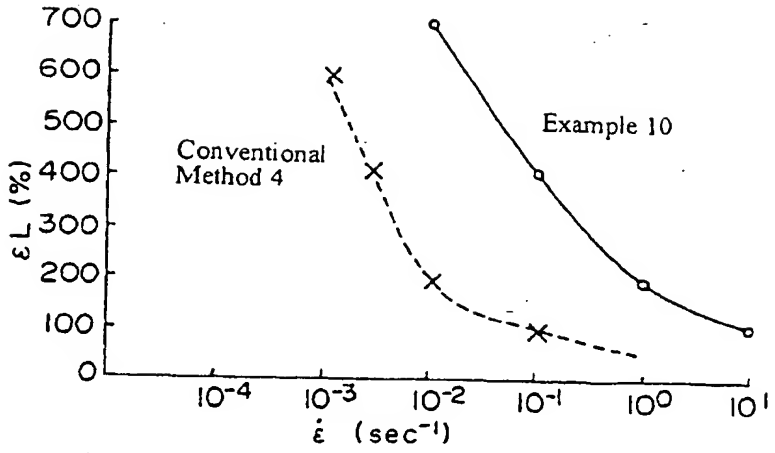
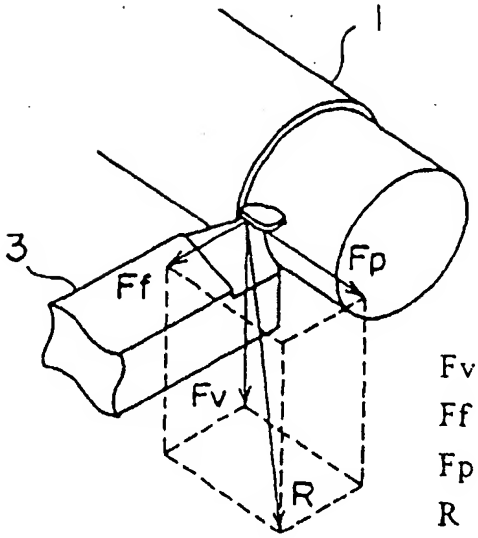


Fig. 6

Sample	Cutting Speed	Cutting Speed (unit :kgf)	Cutting Resistance Index
		Main Component of Force	Main Component of Force in C3604 / Main Component of Force in Each Sample × 100
Reference 3	100 m/min	32.16	79.7
	400	32.37	79.8
Reference 8	100 m/min	28.28	90.6
	400	27.57	93.7
Example 10	100 m/min	28.77	89.1
	400	28.64	90.2
Example 11	100 m/min	29.22	87.7
	400	28.76	89.8
Free Cutting Brass Rod (C3604)	100 m/min	25.63	100
	400	25.83	
Single α-phase (Cu/Zn=65/35)	100 m/min	72.81	35.2
	400	70.57	36.0

Fig. 7



Fv Main component of force
Ff Component of force in feed direction
Fp Component of force perpendicular to feed
R Resultant force

Fig.8

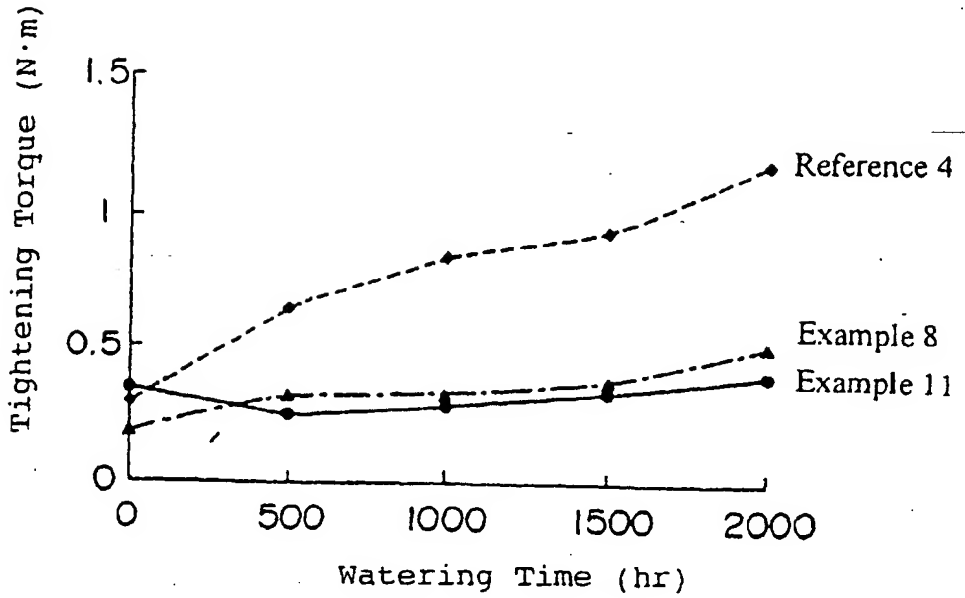


Fig.9

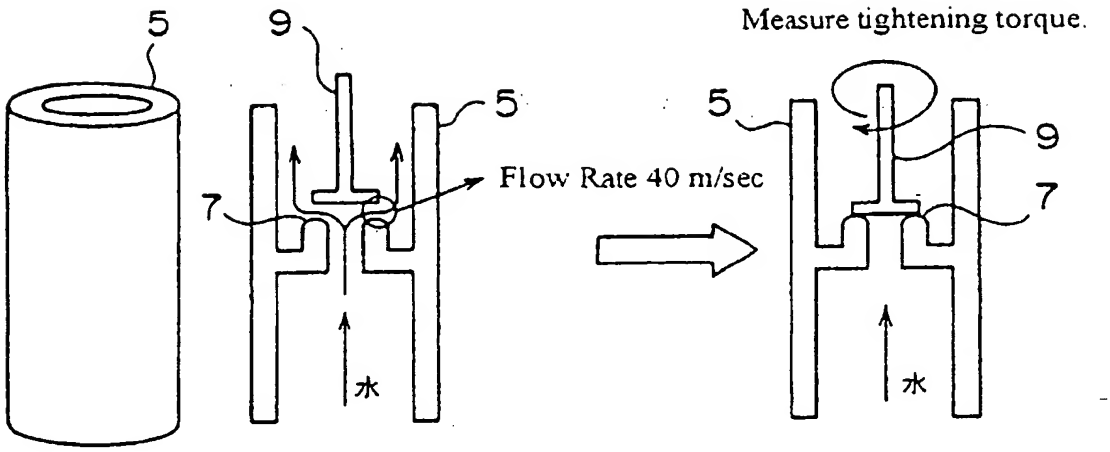


Fig. 10

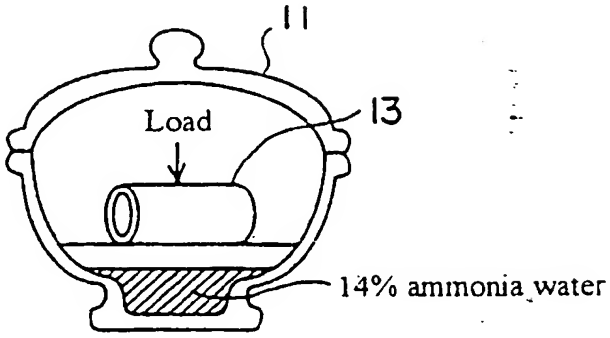


Fig.11

Main Stress	38	87	121	155	189	223	258	292	327	3255
Example 11	○	○	○	○	○	○	○	○	○	×
Example 8	○	○	○	○	○	×	×	×	×	×
Example 15	○	○	○	○	○	×	×	×	×	×
Reference 4	○	×	×	×	×	×	×	×	×	×

○ : No cracking
× : Cracking

Fig 12

No.	Composition (% by wt.)								Apparent Zn Content (% by wt.)	Sn Concentration in β-phase (% by wt.)	Corrosion Resistance	
	Cu	Pb	Fe	Sn	P	Ni	Sb	Zn			Max. Dezincing Corrosion Depth by TBMA Test (μ m)	Judgment
1	61.3	2.0	—	1.0	0.08	0.05	0.03	35.5	39.2	1.3	120	×
2	60.8	2.4	0.2	1.5	0.10	—	—	35.0	40.0	1.4	100	×
3	61.3	2.0	—	1.0	0.08	0.05	0.03	35.5	39.2	1.7	29	○
4	60.8	2.4	0.2	1.5	0.10	—	—	35.0	40.0	2.2	37	○
5	60.8	2.4	0.2	1.5	0.10	—	—	35.0	40.0	3.3	20	○
6	59.6	1.8	0.1	3.0	0.05	—	—	35.5	42.1	4.0	10	○
7	62.9	1.5	—	0.5	0.05	0.05	0.03	35.0	37.3	1.5	55	○

Fig. 13

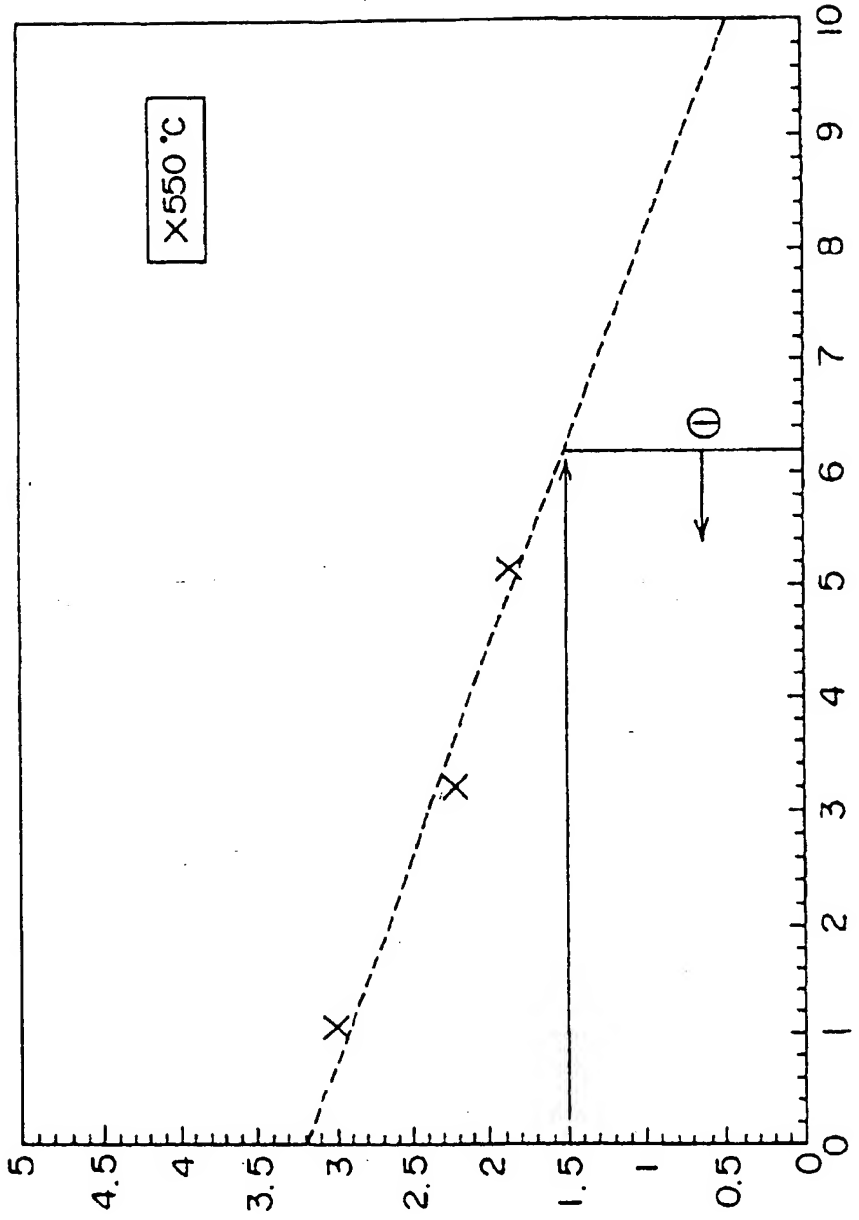


Fig. 14

Heat Treatment		Sn Concentration in β-phase (% by wt.)	Areal Occupation Ratio of β-phase (%)
Temp. (℃)	Time		
475℃	30 sec	1.6	40
	1 min	1.9	40
	8 min	2.3	35
	15 min	2.5	30
	30 min	2.5	25
500℃	30 sec	1.6	40
	1 min	2.1	35
	8 min	3.2	25
	15 min	3.4	20
	30 min	3.6	15
525℃	30 sec	1.7	40
	1 min	2.1	35
	8 min	3.2	25
	15 min	3.5	20
	30 min	3.8	15
550℃	30 sec	1.7	35
	1 min	2.2	30
	8 min	3.2	20
	15 min	3.3	15
	30 min	3.5	10

(Cooling rate: 5 – 1000K/sec down to 400℃)

Fig. 15

FIG. 16A

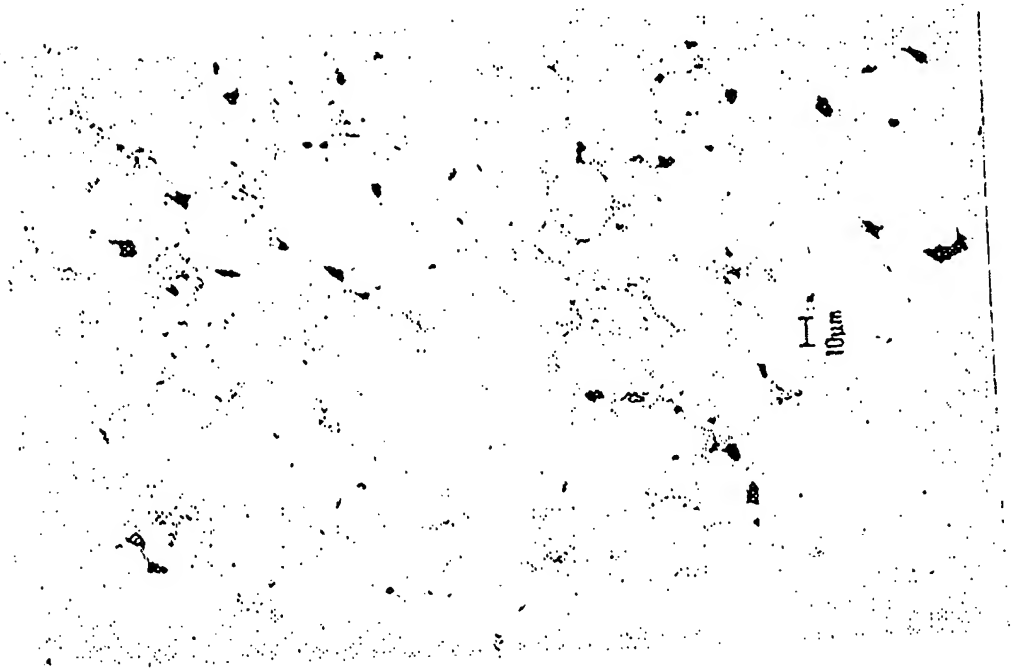


FIG. 16B

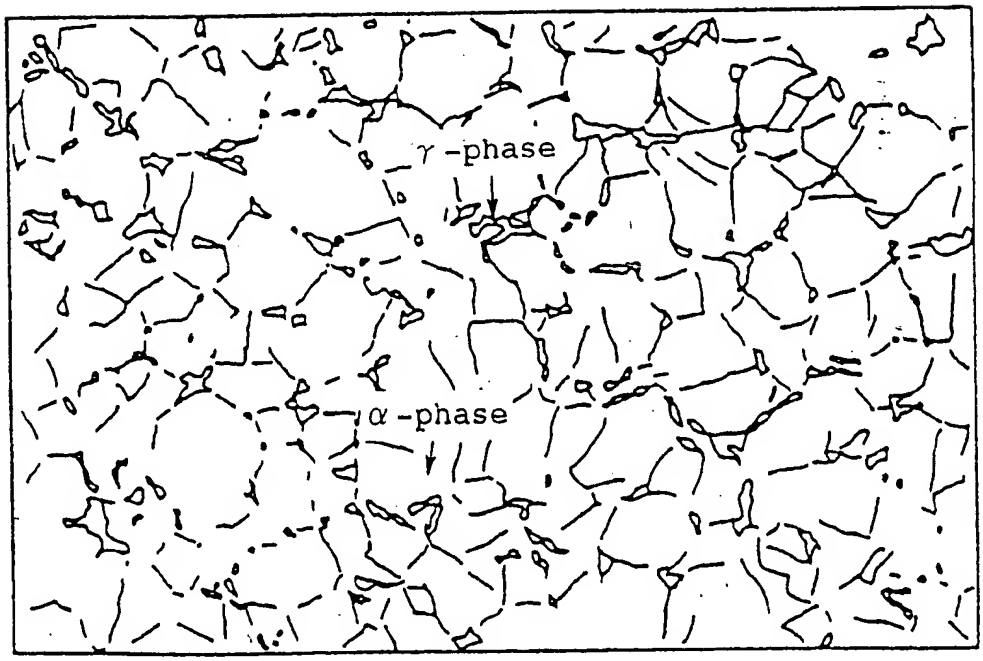


FIG. 17A

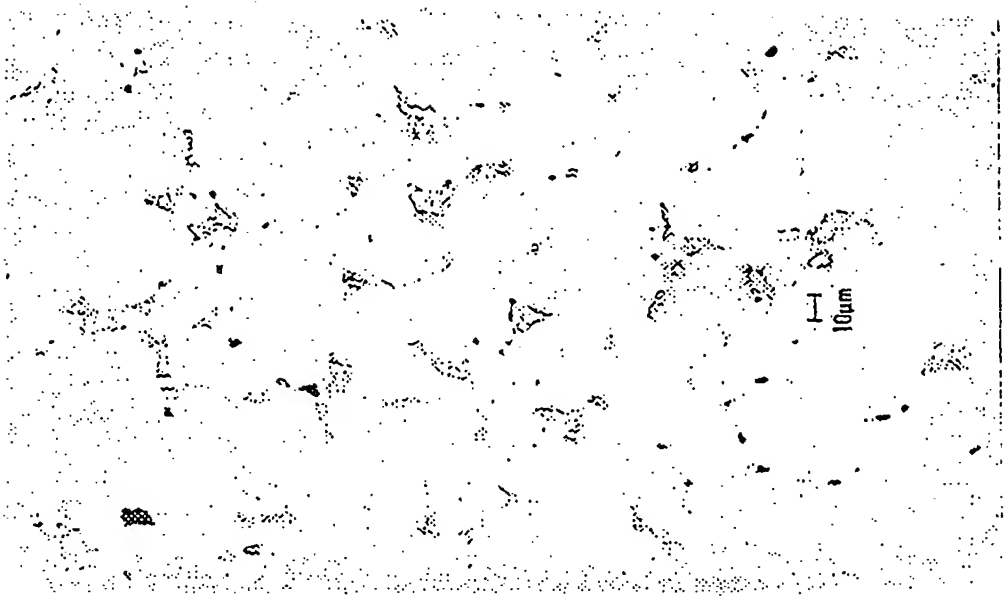
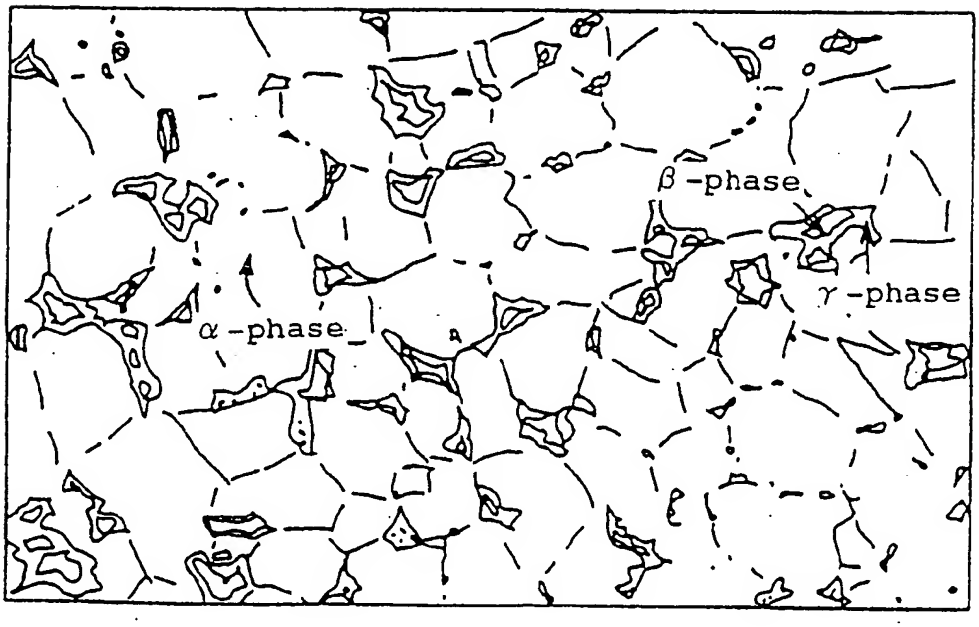


FIG. 17B



No.	Composition (% by wt.)								Apparent Zn Content (% by wt.)	Areal Occupation Ratio of γ-phase (%)	Corrosion Resistance		Sn Concentration in γ-phase (% by wt.)
	Cu	Pb	Fe	Sn	P	Ni	Sb	Zn			Max. Dezincing Corrosion Depth by JBMA Test (μm)	Judgment	
1	61.3	2.0		1.0	0.08	0.05	0.03	35.5	39.2	0.4	120	×	11.4
2	60.8	2.4	0.2	1.5	0.10	—	—	35.0	40.0	1.8	100	×	10.5
3	61.3	2.0	—	1.0	0.08	0.05	0.03	35.5	39.2	3.3	50	○	12.3
4	60.8	2.4	0.2	1.5	0.10	—	—	35.0	40.0	4.2	37	○	11.8
5	60.8	2.4	0.2	1.5	0.10	—	—	35.0	40.0	9.9	20	○	9.5
6	58.0	2.4	0.3	3.0	0.05	—	—	36.3	45.0	20.0	10	○	8.9
7	62.9	1.5	—	0.9	0.05	0.05	0.03	34.2	37.3	3.0	55	○	15.6

Fig. 18

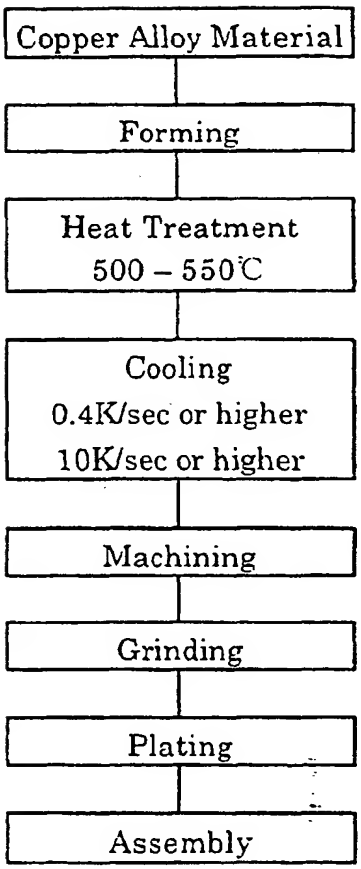


Fig. 19

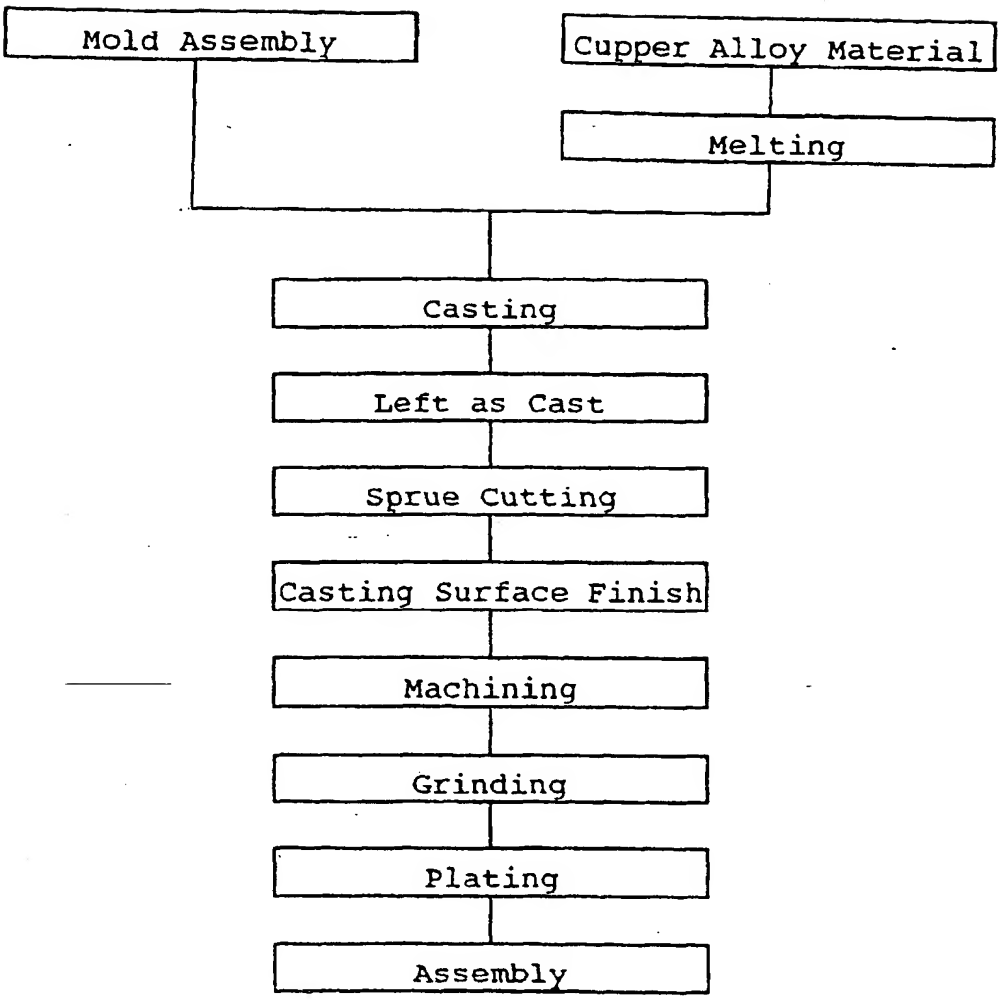


Fig. 20

Heat Treatment		Areal Occupation Ratio of γ-phase	Sn Concentration in γ-phase
Temperature (℃)	Time	(%)	(% by wt)
400℃	30 sec	8	10.7
	1 min	12	5.9
	15 min	15	5.1
	60 min	20	3.0
425℃	30 sec	10	6.8
	1 min	12	5.7
	15 min	15	4.9
	60 min	20	3.1
450℃	30 sec	10	9.7
	1 min	12	9.1
	15 min	15	8.2
	60 min	15	8.5
475℃	30 sec	8	10.3
	1 min	8	10.5
	15 min	8	11.3
	60 min	10	7.0
500℃	30 sec	3	12.2
	1 min	3	12.4
	15 min	3	12.3
	60 min	5	13.0
550℃	30 sec	2	13.1
	1 min	2	12.8
	15 min	2	13.0
	60 min	1	10.5

Fig. 21

FIG. 22A

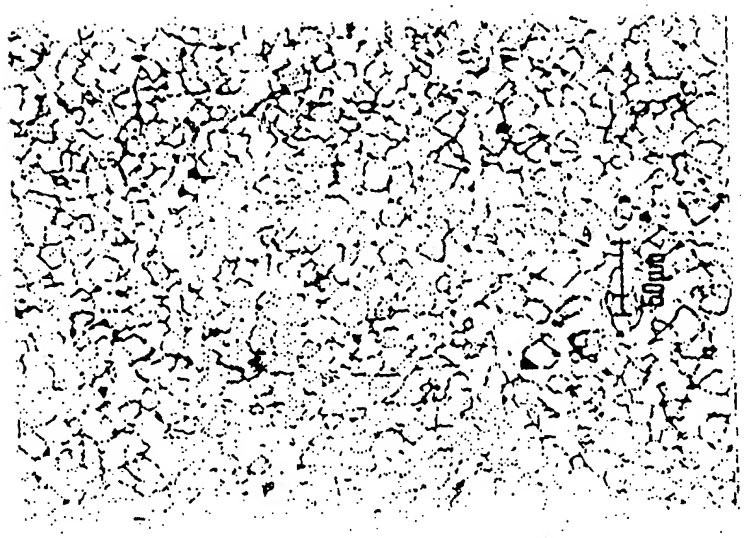


FIG. 22B

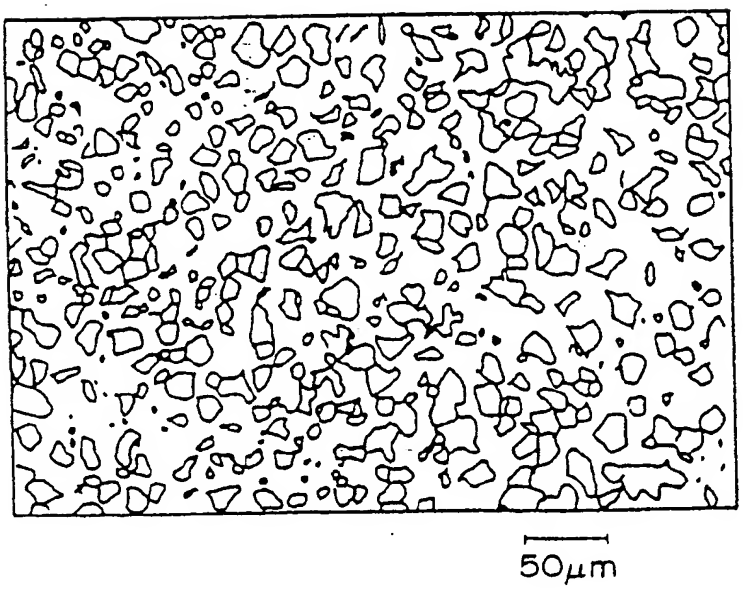


FIG. 23A

FIG. 23B

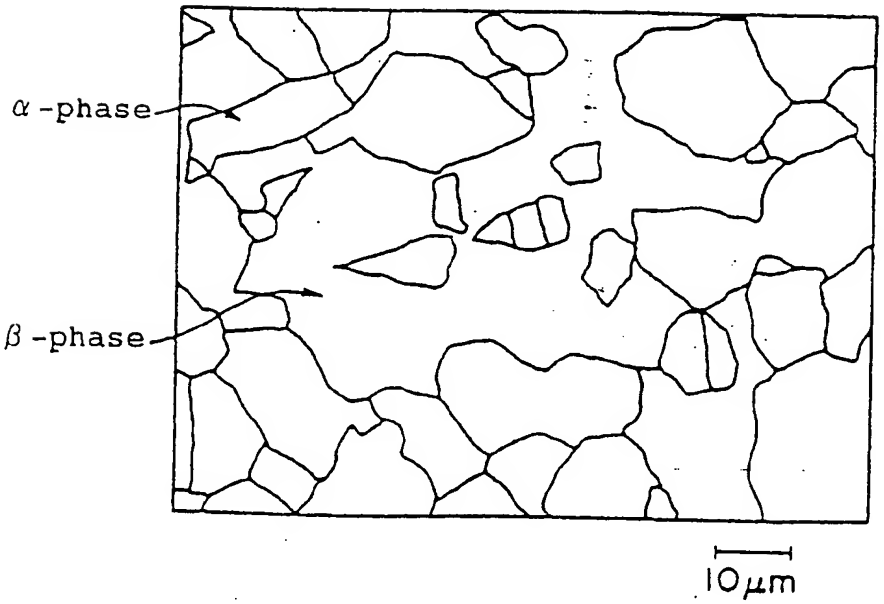


FIG. 24A

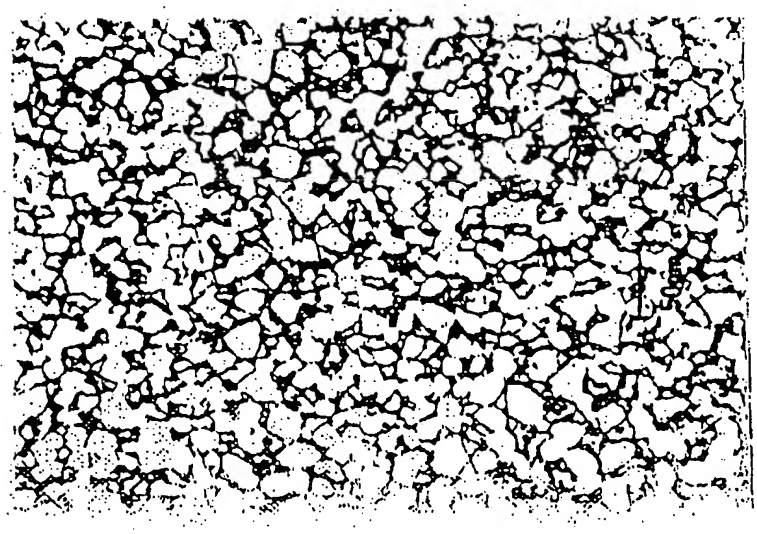


FIG. 24B

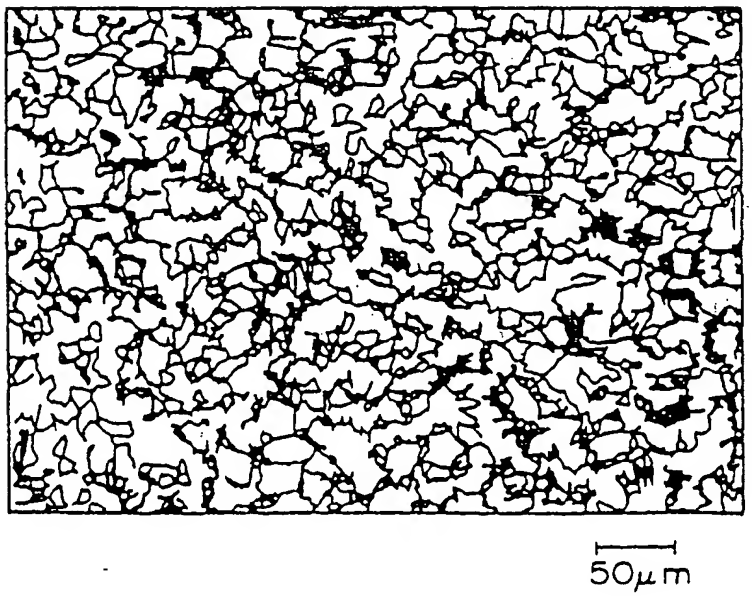


FIG. 25A

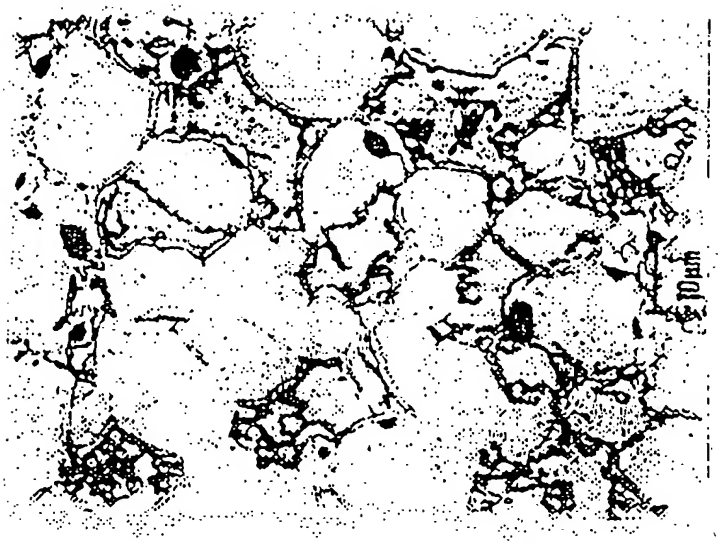


FIG. 25B

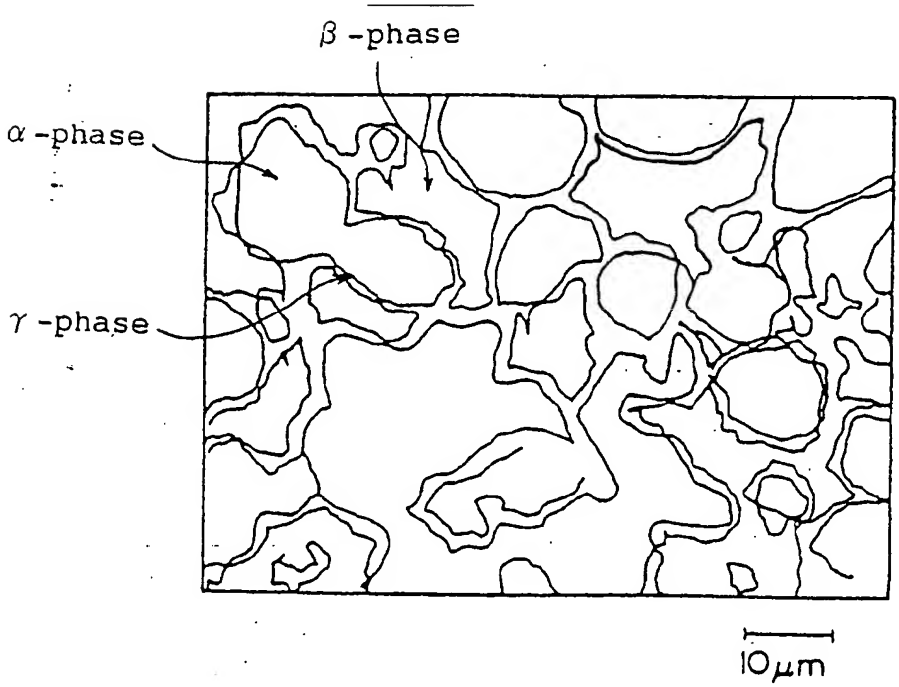


FIG. 26A

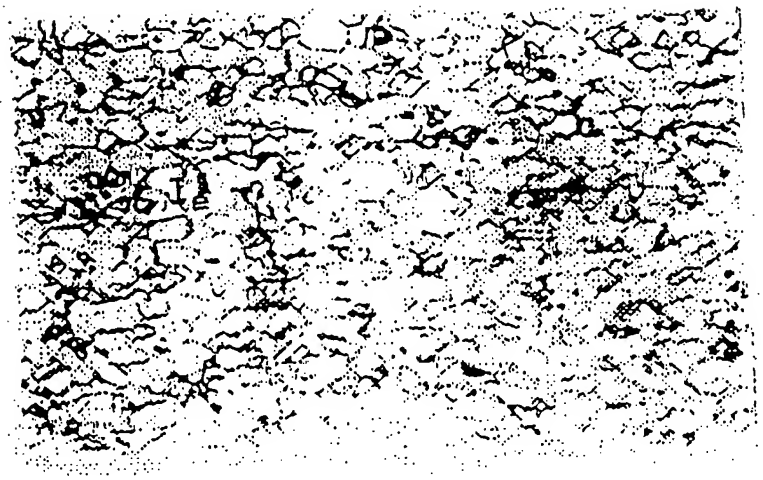


FIG. 26B

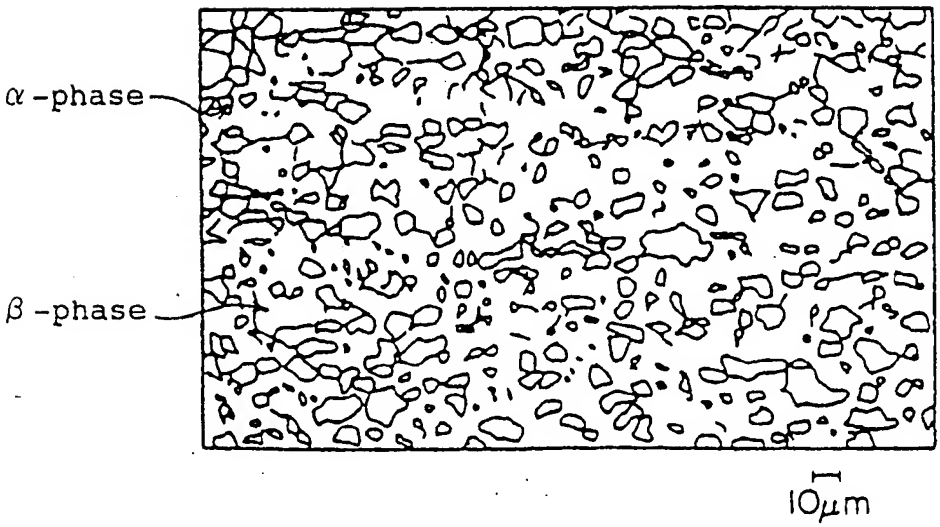


FIG. 27A

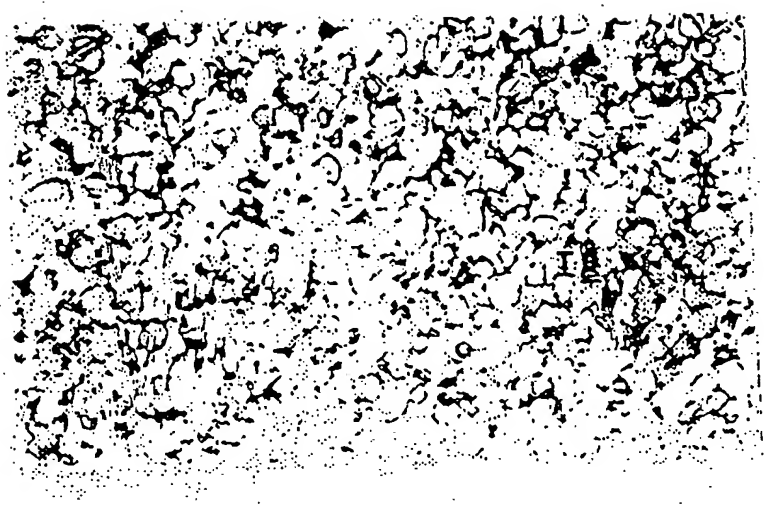


FIG. 27B

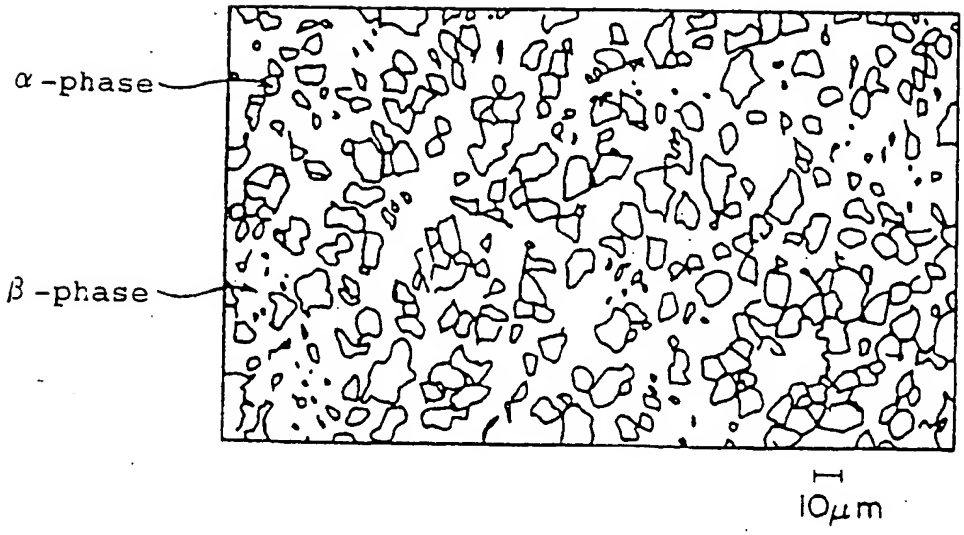


FIG. 28A

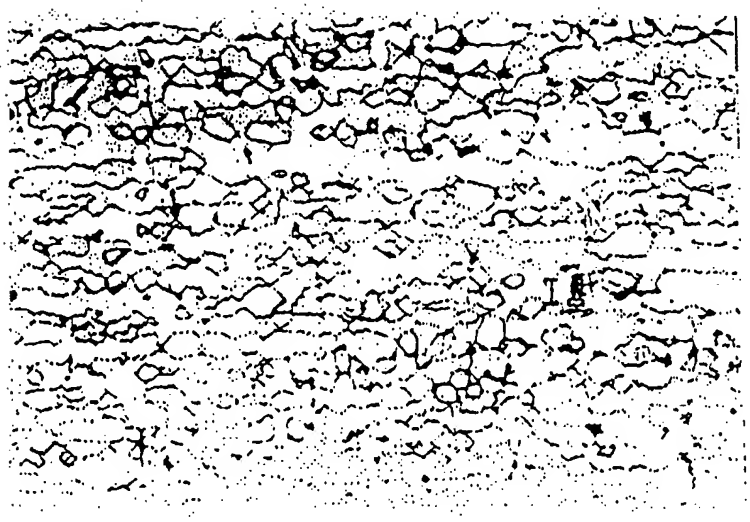


FIG. 28B

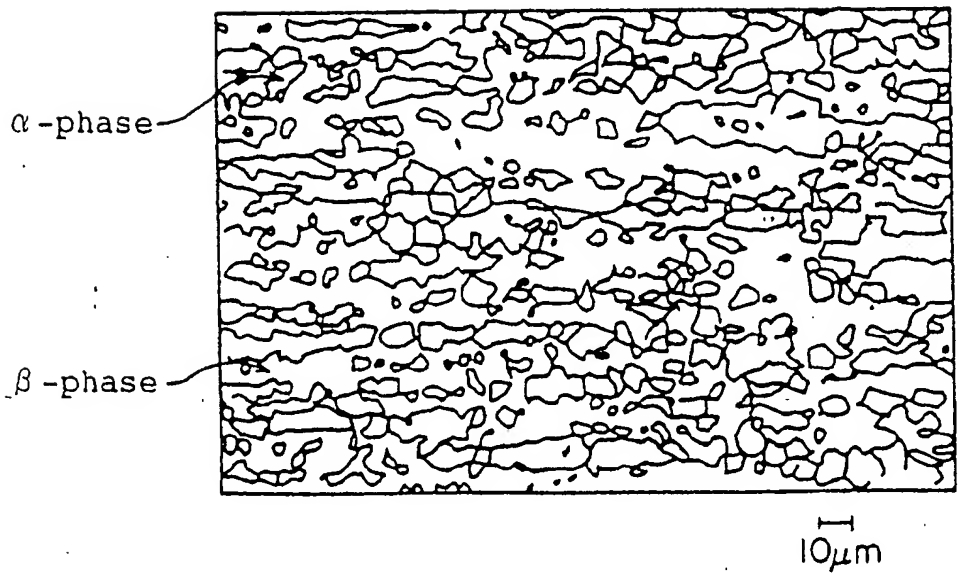


FIG. 29A

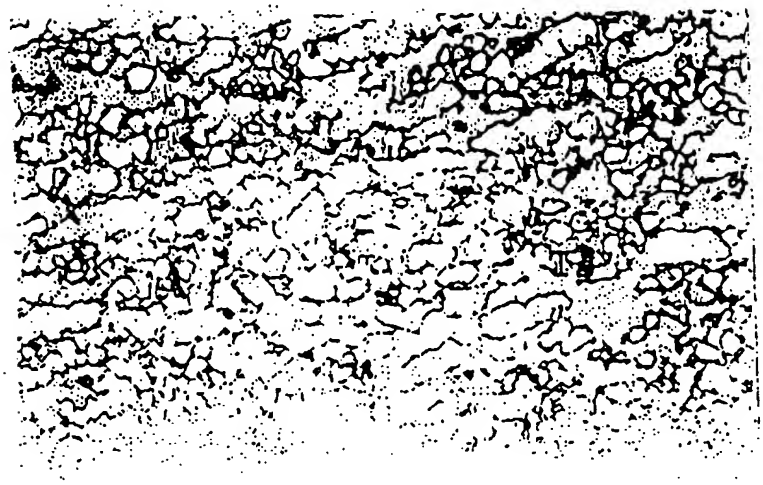
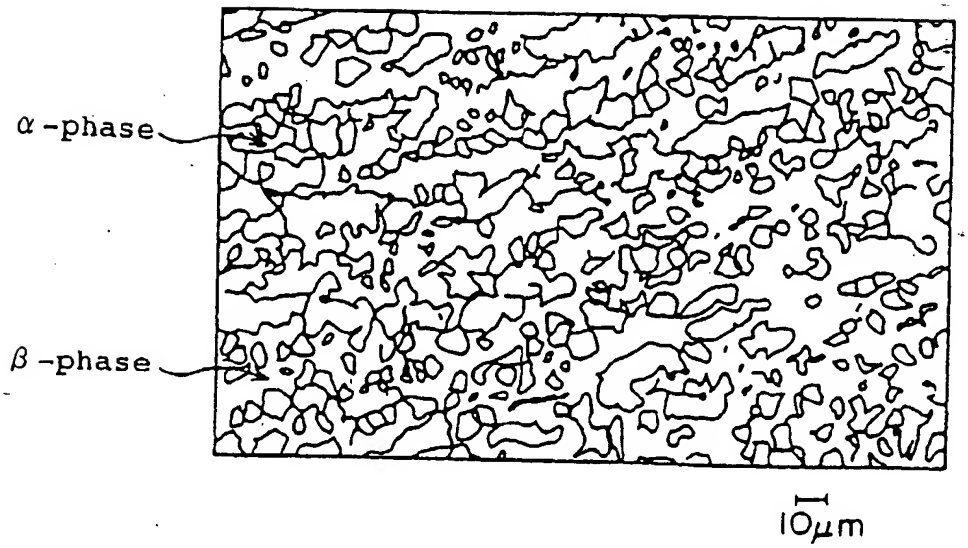


FIG. 29B



Type	Final Crystal Structure at Room Temperature	Crystal Structure in Hot Working	Composition	
			Apparent Zn Content	Sn
$\alpha + \gamma$	α-phase ratio: 97 - 76% (95 - 70) γ-phase ratio: 3 - 30% (5 - 30) Grain size of α-phase: 15 μm or less (10 μm or less) Minor diameter of γ-phase grains: 8 μm or less (5 μm or less) Sn in γ-phase: 8% by wt. or more	$\alpha + \beta$ 2-phases β-phase ratio: 30 - 80% Grain size: 15 μm or less (10 μm or less)	37 - 46% by wt. (38 - 46)	0.9 - 7% by wt.
$\alpha + \beta + \gamma$	β-phase ratio: 3 - 30% γ-phase ratio: 3 - 30% Grain size of α- and β-phase: 15 μm or less (10 μm or less) α-phase ratio: 40 - 94% Minor diameter of γ-phase: 8 μm or less (5 μm or less) Sn in γ-phase: 8% by wt. or more			
α + Normal β	β-phase ratio: 20% or more (25% or more) Grain size of α- and β-phase: 15 μm or less (10 μm or less)		37 - 44% by wt. (38 - 44)	Less than 0.5% by wt.
α + Reinforced β	β-phase ratio: 15% or more (20% or more) Grain size of α- and β-phase: 15 μm or less (10 μm or less) Sn in β-phase: 1.5% by wt. or more			0.5 - 7% by wt.

*: The percentage in parentheses is preferable.

Fig. 30

Type	Production		
	Casting	(1) For Obtainment of Final Structure by Hot Extrusion	
		Hot Extrusion	
α + γ	• Solidification rate $5 \times 10^1 - 10^5$K/sec ($10^2 - 10^4$K/sec) • Cooling rate in solidification 5K/sec or more down to 400℃	• Temperature 480 – 650℃ (600℃ or below) • Reduction of area 90% or more (95% or more)	• Cooling rate 0.4 – 5K/sec down to 400℃
α + β + γ			• Cooling rate 0.4 – 10K/sec down to 400℃
α + Normal β			• Cooling rate 0.4K/sec or more down to 400℃
α + Reinforced β			• Cooling rate 5 – 1000K/sec down to 400℃

Fig. 31

Type	Production		
	(2) For Obtainment of Final Structure by Forging		
	Hot Extrusion	Forging	
$\alpha + \gamma$	• Temperature 480 – 650℃ (600℃ or below) • Reduction of area 90% or more (95% or more) • Cooling rate 0.4K/sec or more down to 40℃	• Temperature 480 – 750℃	• Cooling rate 0.4 – 5K/sec down to 400℃
$\alpha + \beta + \gamma$			• Cooling rate 0.4 – 10K/sec down to 400℃
α + Normal β			• Cooling rate 0.4K/sec or more down to 400℃
α + Reinforced β			• Cooling rate 5 – 1000K/sec down to 400℃

Fig. 32

Type	Production		
	③ For Obtainment of Obtaining Final Structure by Heat Treatment		
	Hot Extrusion	Forging	Heat Treatment
$\alpha + \gamma$	• Temperature 480 – 650℃ (600℃ or below) • Reduction of area 90% or more (95% or more) • Cooling rate 0.4K/sec or more down to 40℃	• Temperature 480 – 750℃ • Cooling rate 0.4K/sec or more	• 30 sec or longer, at 400 – 500℃ • Cooling rate 0.4 –5.K/sec down to 400℃
$\alpha + \beta + \gamma$			• 30 sec or longer, at 450 – 550℃ • Cooling rate 0.4 – 10K/sec down to 400℃
α + Normal β			Not required
α + Reinforced β			• 30 sec or longer, at 475 – 550℃ • Cooling rate 5 – 1000K/sec down to 400℃

Fig. 33

FIG. 34

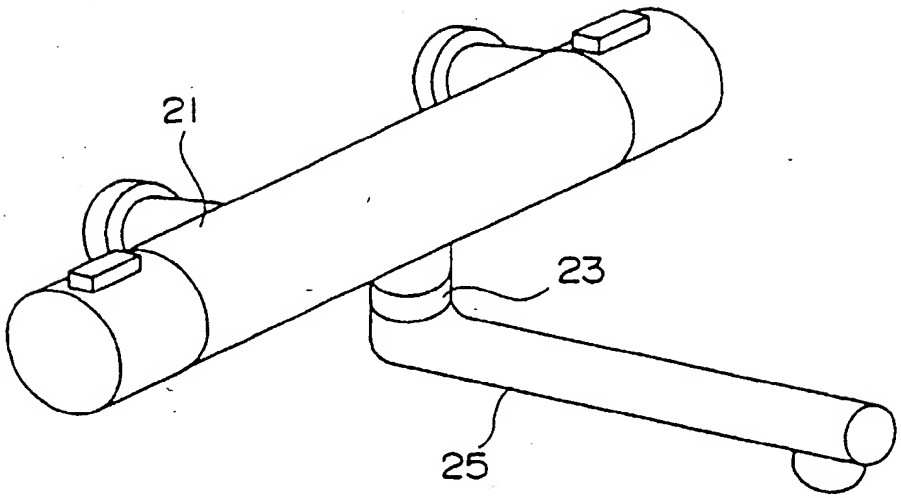


FIG. 35

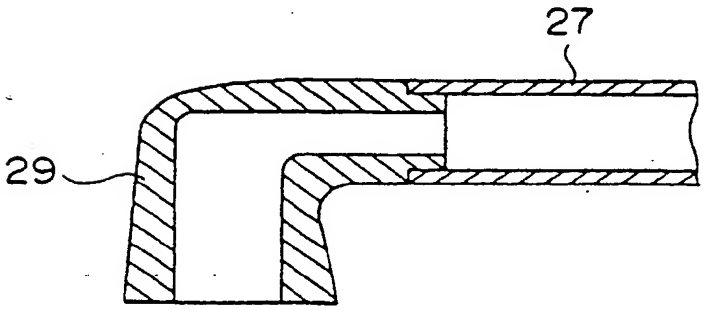


FIG. 36

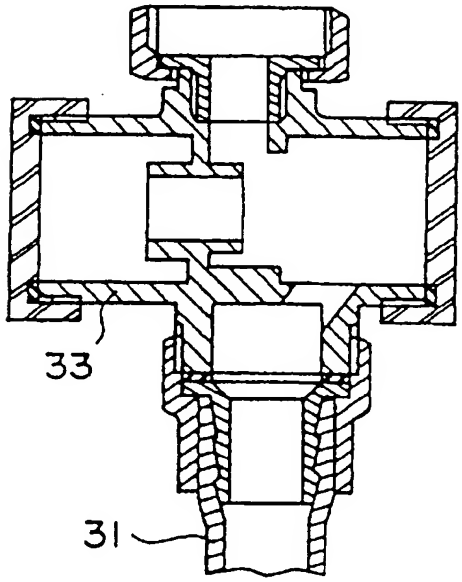


FIG. 37

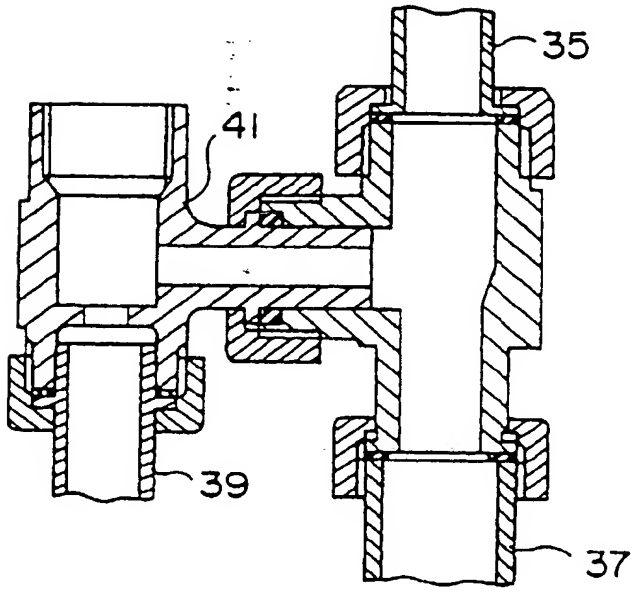


FIG. 38

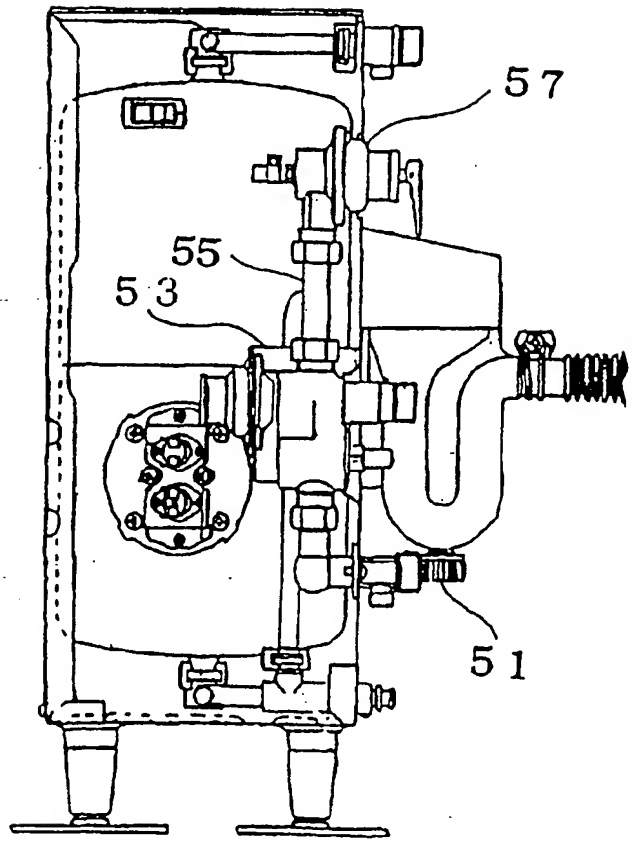


FIG. 39

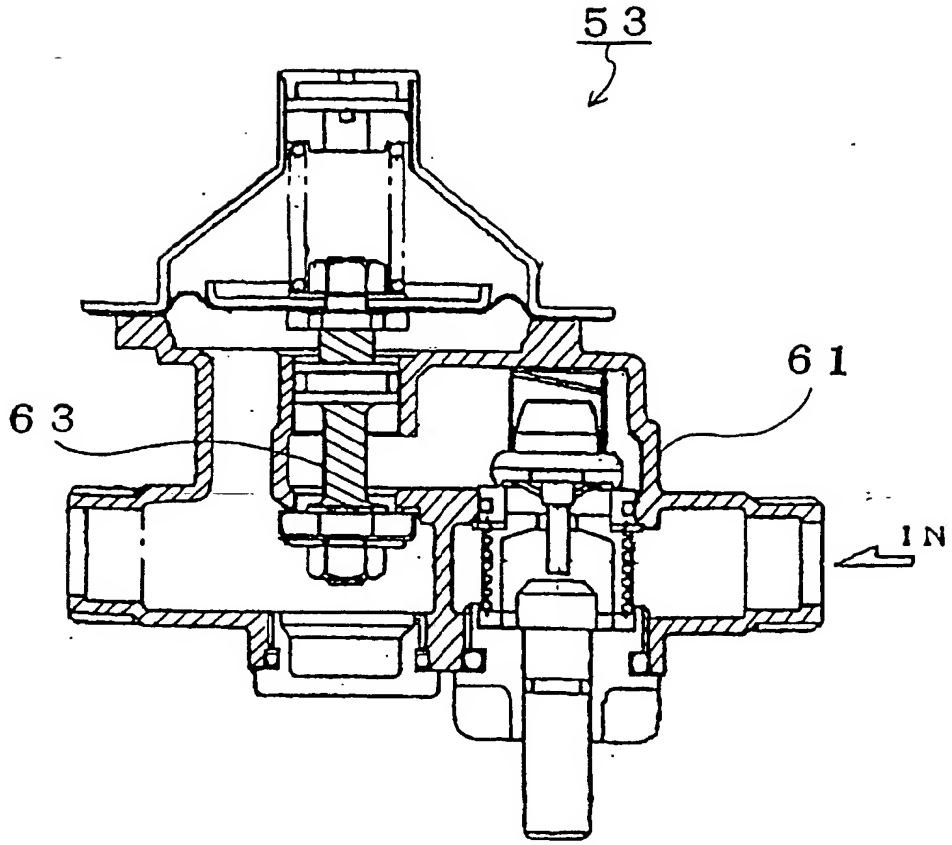
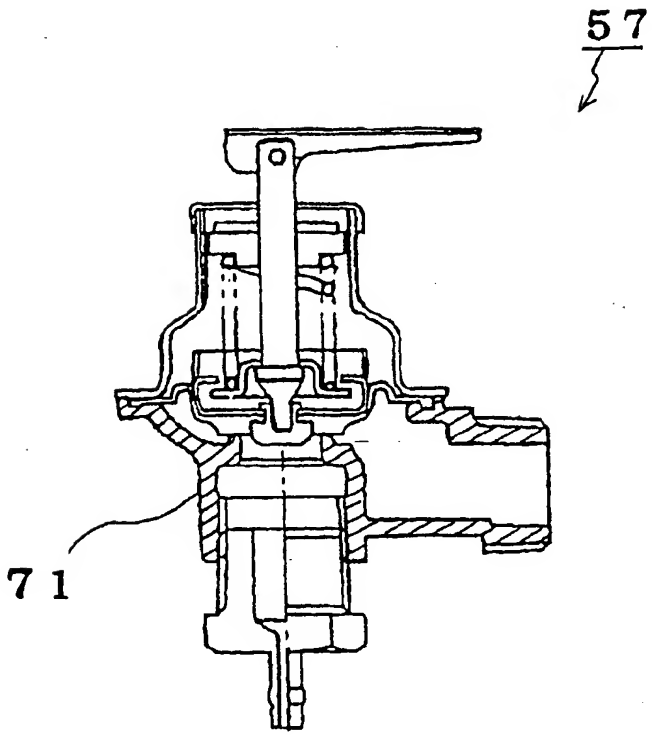


FIG. 40



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP97/03152

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl^6 C22C9/04, C22F1/08
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
Int. Cl^6 C22C9/04, C22F1/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926 - 1996 Jitsuyo Shinan Toroku Koho 1996 - 1997
Kokai Jitsuyo Shinan Koho 1971 - 1997
Toroku Jitsuyo Shinan Koho 1994 - 1997

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
JOIS Ou-Dou, Shinchu, Sessaku, Taishoku, Netsukan, Oshidashi, Chuzo, Sai-Kessho, Netsu-Shori, Datsu-Aen-Fushoku

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	"Journal of the Japan Copper and Brass Research Association", Vol. 22, PP. 231-240 (1983)	1-9, 19-21, 33, 34, 37-57, 62, 69-84, 93-100, 117-124, 129-136, 141-145, 154
X	"Journal of the Japan Copper and Brass Research Association", Vol. 23, PP. 14-24 (1984)	1-8, 10-36, 58-72, 77-80, 85-92, 101-120, 125-132, 137-141, 146-154
X	"Journal of the Japan Copper and Brass Research Association", Vol. 21, PP. 55-63 (1982)	1-11, 13, 15, 22-36, 60, 69-92, 109-120, 125-132, 137-154

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
October 7, 1997 (07. 10. 97)	November 18, 1997 (18. 11. 97)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP97/03152

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Sokeizai, Vol. 37, No. 5, PP. 23-31 (1996)	1-11, 13-16, 22-57, 59, 60, 63-100, 105-154
X	Alloy Dig, No. Jan, PP. 7-8 (1982)	1-11, 22-32, 63-100, 117-120, 125-128, 137-141, 146-153
X	Alloy Dig, No. Jan/Mar, PP. 17-18 (1984)	1-11, 22-32, 35-57, 63-100 125-128, 137-141, 148-153
X	Alloy Dig, No. Aug, PP. 11-12 (1984)	1-11, 22-32, 35-57, 63-100 125-128, 141, 146-153
X	Metall Mater Technol, Vol. 15, No. 4, PP. 199 (1983)	1-7, 22-32, 39-57, 63-72, 97-100, 117-120, 137-141, 146-153
X	JP, 62-243750, A (Japan Energy Corp.), October 24, 1987 (24. 10. 87) (Family: none)	1-8, 22-32, 37-57, 63-72, 93-100, 117-120, 125-141, 146-153
X	JP, 62-60848, A (Japan Energy Corp.), March 17, 1997 (17. 03. 97) (Family: none)	1-9, 22-32, 63-76, 81-84, 125-128, 137-140, 141, 146-153
X	JP, 55-11121, A (Yamanashi Prefectural Government), January 25, 1980 (25. 01. 80) (Family: none)	1-9, 13, 15, 19-21, 33, 34, 37-57, 60, 62, 69-76, 81-84, 93-100, 109-124, 129-136, 141-145, 154

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP97/03152

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 49-23970, B1 (The Furukawa Electric Co., Ltd.), June 19, 1974 (19. 06. 74) (Family: none)	1-11, 13-16, 22-36, 59, 60, 63-92, 105-120, 125-132, 137-141, 146-154
X	JP, 2-129351, A (Mitsubishi Electric Corp.), May 17, 1990 (17. 05. 90) (Family: none)	1-9, 12-21, 33 34, 58-62, 69-76, 81-88, 101-124, 129-136, 141-145, 154
X	JP, 56-84434, A (Olin Corp.), July 9, 1981 (09. 07. 81) (Family: none)	1-9, 13, 15, 22-34, 60, 63-76, 81-84, 109-120, 137-141, 146-154
X	JP, 6-108184, A (Sanpou Shindo Kogyo K.K.), April 19, 1994 (19. 04. 94) & DE, 4233668, C2	1-18, 22-120, 125-132, 137-141, 146-154
X	JP, 3-170647, A (Japan Energy Corp.), July 24, 1991 (24. 07. 91) (Family: none)	1-9, 22-34, 37-57, 63-76. 81-84, 93-100, 117-120, 125-132, 137-141, 146-154
X	JP, 57-51233, A (Kitazawa Valve K.K.), March 26, 1982 (26. 03. 82) & US, 4417929, A	1-8, 13, 15, 22-32, 37-57, 63-72, 93-100, 109-120, 125-128, 137-141, 146-153
X	JP, 49-55520, A (Toyo Valve Co., Ltd.), May 29, 1974 (29. 05. 74) (Family: none)	1-11, 13, 15, 35-57, 60, 69-100, 109-116
X	JP, 60-56037, A (Dowa Mining Co., Ltd.), April 1, 1985 (01. 04. 85) (Family: none)	1-11, 22-57, 63-100, 117-120, 125-132, 137-141, 146-154

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP97/03152

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 1-272734, A (Kobe Steel, Ltd.), October 31, 1989 (31. 10. 89)(Family: none)	1-9, 19-21, 37-57, 62, 69-100, 117-124, 133-136, 141-145
X	JP, 7-310133, A (Chuetsu Metal Works Co., Ltd.), November 28, 1995 (28. 11. 95)(Family: none)	1-11, 22-32, 35-57, 63-100, 137-140, 146-153
X	JP, 7-207387, A (Kitz Corp.), August 8, 1995 (08. 08. 95)(Family: none)	1-8, 13, 15, 19-34, 37-57, 60, 62-72, 93-100, 119-154
X	JP, 5-345939, A (Nippon Mining & Metals Co., Ltd.), December 27, 1993 (27. 12. 93)(Family: none)	1-13, 15, 17, 18, 35, 36, 58, 60, 61, 69-92, 101-116

* Form PCT/ISA/210 (continuation of second sheet) (July 1992)